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The Editors Note . .

THERE is real excitement in astronomy, but who would expect it to come in connection with such a well-known and long-observed star as Algol?

Jesse A. Fitzpatrick, who compiles our Observer's Page, sent us times for the minima of Algol in January which were a continuation of those published in *The Observer's Handbook* last year. However, proof of its January page reached us (through the kindness of Dr. F. S. Hogg) just as our January issue went to press. Knowing that Mr. Fitzpatrick had relied upon the *Handbook* last year, we changed his times to agree with the 1942 edition.

In connection with his article on Algol in this issue, Dr. Zdenek Kopal gave us a schedule of February minima which agreed neither with Mr. Fitzpatrick nor the *Handbook*. We asked him to write the note which is in the adjoining column.

In *Popular Astronomy* for January, there is an article by Mary R. Hunt, which discusses the reasons for minor discrepancies in Algol predictions.

Adding Joseph Ashbrook's 25 minutes to Dr. Kopal's 8:00 p.m. for the January 1st minimum gives 8:25 p.m., or just the time Mr. Fitzpatrick refers to in his letter to us, which is printed in part on the Observer's Page this month.

A COMMITTEE is now engaged in preparing an outline of a college course, in astronomy and mathematics as related to air navigation, to serve as preparation for the Army Air Corps training course for navigators. This is being done under the auspices of the A.A.A.S. and the committee is composed of W. L. Hart, Minnesota, W. M. Whyburn, California at L. A., and C. C. Wylie, Iowa.

The outline, with references to books in which the material may be obtained, will be ready in time for spring college courses. The secretary of the American Astronomical Society has been asked for a list of all institutions in which there is a possibility of such a course being given in the semester beginning this month. Therefore he asks interested educators to write by return mail (Dr. Dean B. McLaughlin, University of Michigan Observatory, Ann Arbor, Mich.), answering the following questions:

Are you equipped to conduct courses in celestial navigation; more particularly, aerial navigation?

If you cannot carry on such work, is there any member of the faculty of your institution who could do so?

Dr. McLaughlin says that these courses in colleges and universities should prepare men for the army course, which is already established, without unnecessary duplication of material. Dr. F. R. Moulton, permanent secretary of the A.A.A.S., says: "As I see it, the mathematicians and astronomers of the country will have to carry these courses. . . . If they solve the problem to any considerable extent they will contribute enormously to our armed forces and will bring into sharp focus the value of their sciences to society."

Sky and TELESCOPE

Charles A. Federer, Jr., *Editor*   Helen Spence Federer *Managing Editor*

PREDICTIONS OF ALGOL MINIMA

THE deep minima of Algol in February should be observable at the following times: (E.S.T.) Feb. 5—5:47 a.m., 8—2:37 a.m., 10—11:25 p.m., 13—8:14 p.m., 28—4:19 a.m. (This corresponds to a minimum on January 1, 1942, at 8:00 p.m.)

According to *The Observer's Handbook for 1942*, published by the Royal Astronomical Society of Canada, the minima should occur approximately 57 minutes later. This discrepancy is, however, due to a difference in the epochs adopted. My ephemeris is computed from the minimum accurately observed by Hall at Amherst with the aid of a photoelectric photometer on December 1, 1938. According to Hall (*Ap. J.*, *90*, 449, 1939) the heliocentric minimum occurred at J. D. 2429234.686 ± 0.001.

A letter from Dr. F. S. Hogg to the editor of *Sky and Telescope* states that the minima of Algol in *The Observer's Handbook for 1942* are based on a minimum visually observed by S. Gaposchkin on December 4, 1938 (*Pop. Ast.* *47*, 51, 1939). For the time of this minimum Gaposchkin gave J. D. 2429237.595. This minimum succeeds immediately that observed by Hall; but their difference of 2.909 days exceeds the true period of Algol by 0.042 days. In view of the technique employed, Hall's determination carries undoubtedly much more weight and makes it very probable that Gaposchkin's minimum, which served as a basis for the 1942 *Handbook*, is off by about one hour. A correction of 48 minutes should be applied to the epoch recently published by Mary R. Hunt (*Pop. Ast. 50*, 21, 1942).

As also noted in the same issue of *Popular Astronomy*, page 56, in the monthly Variable Star Notes, in November, 1941, Ashbrook observed Algol visually at Harvard and suggested that the minima actually occur about 25 minutes later than computed. More observations are urgently needed to confirm this result, for if Algol is really at present half an hour behind schedule, our worries with this capricious star will be greatly increased.

ZDENEK KOPAL

Vol. I, No. 4   CONTENTS   February, 1942

COVER: F. G. W. Struve (1793-1864), first director of Poulkovo Observatory. This engraving is dated 1844.

BACK COVER: One of the newest additions to the ranks of a comparatively new type of telescope, the Burrell 24-36-inch Schmidt telescope was dedicated during the recent meetings of the American Astronomical Society (see story on page 14). The instrument is at the Warner and Swasey Observatory of the Case School of Applied Science, Cleveland, Ohio. The cutaway drawing by Russell W. Porter shows the mirror at the lower end of the tube, with the correcting plate at the upper end, and the photographic plateholder in the middle. Engraving, courtesy, Warner and Swasey Observatory.

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Entered as second class matter, April 28, 1939, at the Post Office, New Rochelle, N. Y., under Act of March 3, 1879.

A general view of historic Poulkovo Observatory. The revolving turret of the 15-inch refractor appears in the center. Behind the tree at the right is the dome of the 30-inch Clark pictured below. In the foreground is Otto Struve, Sr., with his grandson, George Struve, who later became astronomer at the Neubabelsberg Observatory near Berlin.

THE POULKOVO OBSERVATORY (1839-1941)

BY OTTO STRUVE

Director, Yerkes and McDonald Observatories

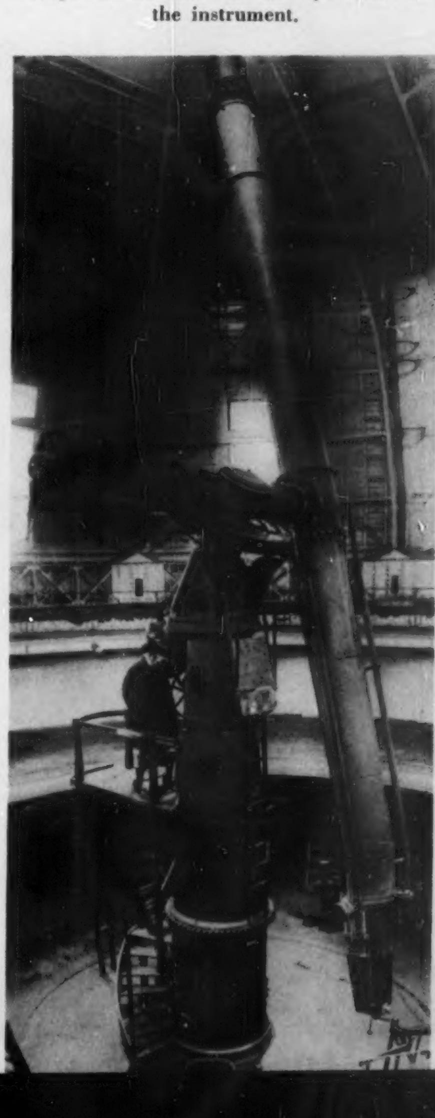
THE October, 1941, issue of *The Observatory* contains the following brief notice: "... news has been received of the destruction of the historic Pulkovo Observatory, in the fighting near Leningrad. The Observatory celebrated its centenary in 1939 and its loss will be felt with grief and horror by all astronomers." History will record the name of Adolf Hitler along with that of Khalif Omar, whose General Amru in 641 A.D. finished by fire the destruction of the great library in Alexandria, and that of the patricide Abdallatif who, in 1449, murdered his illustrious father, Ulugh Beigh, and thus brought to an end the work of the great observatory at Samarkand.

B. A. Gould once called the Poulkovo Observatory "the astronomical capital of the world," and in 1903 Simon Newcomb wrote:[1] "The instruments which Struve designed sixty years ago still do as fine work as any in the world. . . . The air is remarkably clear. The entrance to St. Petersburg, ten or twelve miles north, is distinctly visible, and Struve told me that during the Crimean war he could see, through the great telescope, the men on the decks of the British ships besieging Kronstadt, thirty miles away."

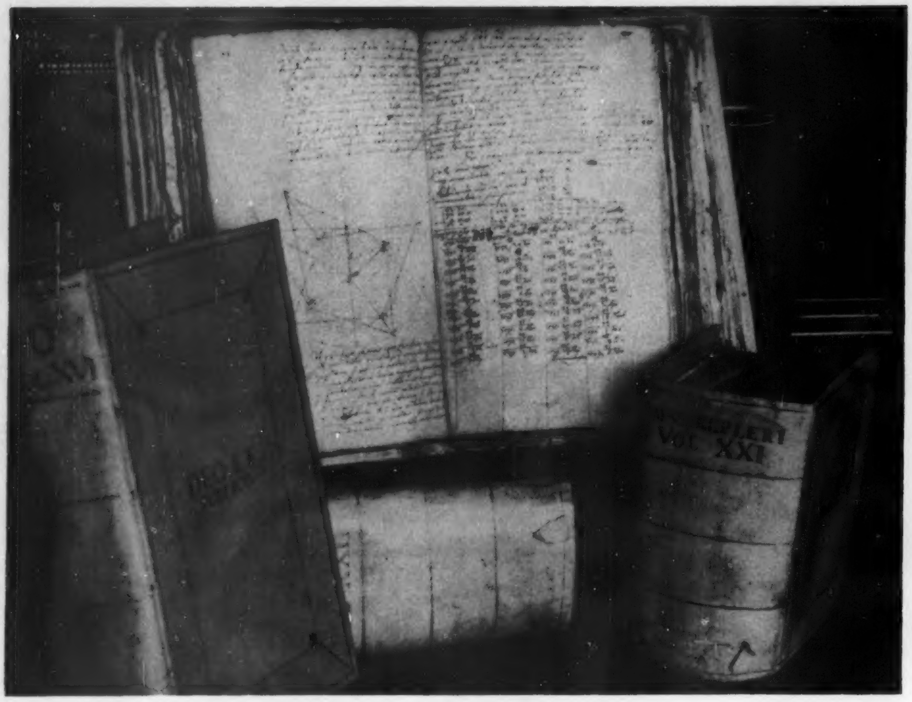
In 1919, the White Russian forces under General Udenich besieged Poulkovo for several days and shells burst among its buildings. But no serious damage was done. The lenses had been dismounted and stored underground. The personnel was not injured and Poulkovo again became the center of all astronomical activities in Russia.

To recall the beginning of the Poulkovo Observatory, let us turn back to the year 1808. One day in summer a boy of 15 was walking through the fields near his native town of Altona, then a part of Denmark. The world was in turmoil. A powerful and reckless dictator had conquered nearly all of Europe, and only two countries—England and Russia—were blocking his progress toward world domination. Napoleon was determined to conquer Russia and even then was preparing an army for the drive against Moscow. But Denmark was neutral and the boy, a Danish subject on Danish soil, had no thought but that of safety under the neutrality laws of that time. He was about to learn that dictators may disregard the rights of citizens in neutral countries, for he was accosted by French recruiting officers who demanded that he join the French army and, when he refused, abducted him. He was taken to Hamburg where his captors locked him in a room of a two-story building overlooking the River Elbe. Young F. G. W. Struve had no desire to compromise. When all was quiet at night he opened a window and jumped into the water below. He was strong and a good swimmer, and he struck out in the direction of a ship in the harbor. The ship was Russian, ready to set sail for Riga. Struve was taken aboard and sailed

The 30-inch refractor built by Alvan Clark; mounting by Rhepsold. On the platform at the manual controls is Dr. A. A. Belopolsky. The stellar spectroscope is attached at the eye end of the instrument.



[1] *Reminiscences of an Astronomer*, Cambridge, 1903, p. 312.



Books from the Poulkovo collection of original Kepler manuscripts.

to Russia, determined to make a home for himself in a new land.

He worked his way through the University of Dorpat where he first took up the study of ancient history and philology, but soon switched to astronomy and mathematics. A few years later he became the director of the observatory at Dorpat, and undertook with the new 10-inch refractor the extensive measurements of double stars which in 1837 led to the publication of the *Mensurae Micrometricae.*

Struve knew that the capital of Russia, St. Petersburg, had only a small and inadequately equipped observatory. One of its instruments was a telescope permanently fixed on a wall toward that point in the sky where the star Vega crosses the meridian. Evidently, the purpose of the instrument had been to determine the parallax of Vega—a task which had not been completed. This point is of interest in connection with his later success in determining the first reliable parallax of a fixed star, and the name of this star was Vega.

In 1834 Struve was presented to the Czar Nikolai and obtained from him permission to draw up plans for a new large observatory. The cornerstone was laid in 1835, and the opening of the new institution took place on August 19, 1839. The principal instruments were a 15-inch refractor by Fraunhofer, a large transit instrument made by Ertel for obtaining accurate star positions in the prime vertical, and an equally powerful meridian circle by Rhepsold. The refractor — then the largest in the world—was used for double-star observations, first by the son of the founder, Otto Struve, and later by his grandson, Hermann Struve. More recent series of observations with this instrument were carried out by Serafimov (1892-1900), Okulich (1898-1905), Neujmin (1911-12), Vyssotsky (1913-16), Pokrovsky (1921), and Komendantoff (1926-35).

Most of the early work of the observatory was devoted to the observation of accurate star positions. These were used by F. G. W. Struve for the determination of the constant of aberration, for which he gave in 1843 the value 20".4451—remarkably close to the modern value of 20".47. From the constant of aberration he determined the velocity of light as "497.8 seconds, corresponding to the mean distance of the sun from the earth."

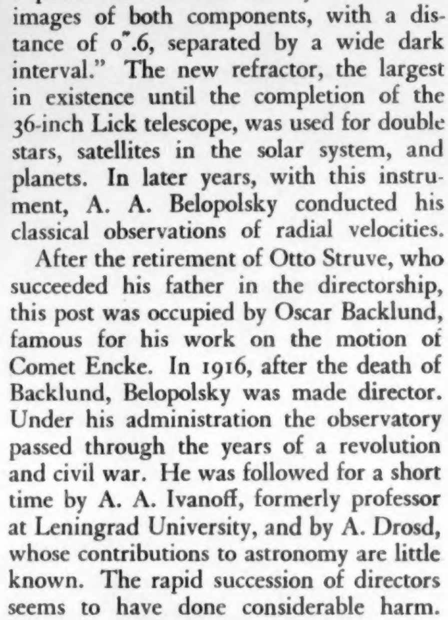
Other problems concerned the constant of precession and the motion of the solar system with respect to those stars for which proper motions were known. The work on stellar parallaxes, commenced at Dorpat, was vigorously continued at Poulkovo. The data obtained by several astronomers during the first eight years of the life of the observatory formed the foundation for a new picture of the stellar system described in a book entitled *Etudes d'Astronomie Stellaire.* This book contains the first observationally and theoretically sound treatment of the problem of interstellar absorption.

In a recent volume of the *Annals* of the observatory, one of the principal tasks of Poulkovo is described as "the observation of a fundamental catalogue of several hundred stars at intervals of about twenty years, for the purpose of constructing a reference system and deriving accurate proper motions." The numbers of the stars in the Poulkovo catalogues are 374 in 1845, 382 in 1865, 382 in 1885, 549 in 1905, and 558 in 1930. With regard to the precision of these observations, M. Zverev states:[2] "The method of separately determining each coordinate of a star . . . has been fully justified, and is at present used by all Soviet meridian observers. The Poulkovo catalogues have always been given higher weights than the catalogues of Greenwich where both coordinates are determined simultaneously with a single instrument."

In 1878, the observatory installed a new 30-inch refractor with a lens by Alvan Clark. Five years later, the director (whose brother was at that time the Russian Ambassador in Washington) came to the United States and tested the objective. The star "42 Comae was examined with a power of 1800 and clearly showed the images of both components, with a distance of 0".6, separated by a wide dark interval." The new refractor, the largest in existence until the completion of the 36-inch Lick telescope, was used for double stars, satellites in the solar system, and planets. In later years, with this instrument, A. A. Belopolsky conducted his classical observations of radial velocities.

After the retirement of Otto Struve, who succeeded his father in the directorship, this post was occupied by Oscar Backlund, famous for his work on the motion of Comet Encke. In 1916, after the death of Backlund, Belopolsky was made director. Under his administration the observatory passed through the years of a revolution and civil war. He was followed for a short time by A. A. Ivanoff, formerly professor at Leningrad University, and by A. Drosd, whose contributions to astronomy are little known. The rapid succession of directors seems to have done considerable harm. The period between 1920 and 1932 was

(*Continued on page* 19)



At the time of the Siberian eclipse, 1936, American astronomers visited Dr. B. P. Gerasimovich, then director at Poulkovo. Dr. Donald H. Menzel, of Harvard, snapped this picture of him at his desk. No word has been received about Dr. Gerasimovich since 1937.

[2] *Russian Astronomical Journal,* 14, 395, 1937.

WAVES FROM SPACE

By William H. Barton, Jr.

The story of the analysis of energy which falls upon the earth and enables us to study distant objects is told here and in the Hayden Planetarium this month.

Secrets of the external galaxies, such as NGC 55 pictured here, are revealed by an analysis of their light.

EVEN the credulous ancients would not have believed it. They may have thought that the sun was carried across the sky in a flaming chariot, and that thunder and lightning were the effects of Olympian battles. They may have pictured comets as flaming swords and planets as gods, but they certainly would not have been willing to credit us with what we have learned by studying waves from space.

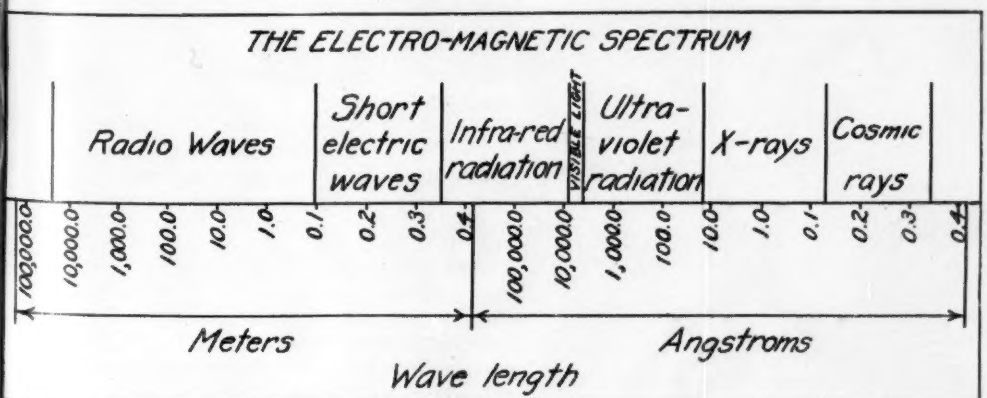
If they could ask us about the nature of these things we call waves, we might find ourselves in a somewhat embarrassing position. We could explain that by waves we mean radiation. The stars send out light and other kinds of radiation that we have learned to analyze. Along with the light we receive other kinds of "radiation": electrical energy, cosmic rays. Our explanations might sound to the scientist of 6939, when the Time Capsule is opened, as queer as the theories of 2,000 years ago sound to us. So let's not delve into the explanations but into the effects.

By means of this radiation from space we have learned things about distant bodies. The study of light has given us a means of finding the distances, the sizes, the temperatures, the makeup, the motions, the speeds, and even an insight into the life histories, of stars. We also learn things about the earth by studying light from the stars, such as its size, shape, motion, and distance from the sun.

It is difficult to say when this utilization of light waves was begun, but it was long before it occurred to anyone to study light itself in order to discover its less obvious properties. We think of a light beam as traveling in a straight line through empty space. It may not, but that is a matter that had better be reserved for another article in *Sky and Telescope* about 6939 A.D. However, at present we know that as starlight enters the earth's atmosphere, it is bent by refraction, which causes the star to appear a little lower in the sky. The difference becomes greater as the object approaches the horizon. And in making an observation for a star's position we have to allow for this bending effect. It is important, then, that our knowledge of physics keep pace with our study of the sky, to discover unsuspected properties of waves from space.

One of the first measurements using light beams was that made by Eratosthenes about 200 B.C. He noted that at noon on June 21st the sun shone down a well in Syene. At the same time an obelisk in Alexandria cast a shadow that indicated the sun's position as 7½ degrees from the zenith. These places were 500 miles north and south of each other. Setting up a proportion: 7½ degrees is to 500 miles as 360 degrees is to the earth's circumference, the answer comes out 24,000 miles, which is not far from our present value. Perhaps many people in Columbus' time thought the earth was flat, but 1,700 years earlier this Greek philosopher had measured it as a globe—and he used waves from space.

By the same token the skipper of a ship or the navigator of a plane finds his way over the earth. The trackless ocean is sailed by lighthouses in the sky. And a plane flying above the clouds charts its course by looking up, not down. There were maps of the sky long before there were maps of the earth.



Waves from space are not confined to visible light alone—in fact, it is but a small portion of the spectrum of radiant energy.

This year we are celebrating the 300th anniversary of the birth of Sir Isaac Newton. It was he, who first seriously examined light. Using a prism, he resolved light into its component colors, and thus began a new science. It is an old story but an important one to the astronomer.

The nature of light had always been a puzzle—and is yet, for that matter. Newton was convinced that light was really a stream of tiny particles shot off from a body like a stream of machine-gun bullets. This is generally called the corpuscular theory.

The Dutch physicist, Christian Huyghens, on the other hand, taught the wave theory of light. He contended that light represented wave motion in a medium that has come to be known as ether.

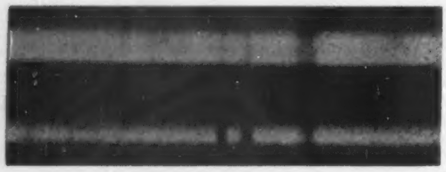
Up to the turn of our century, the wave theory prevailed against Newton's corpuscular notions. But since then the older theory has been coming forward somewhat—not displacing the wave theory, but taking its place alongside it. The problem now is to find something all-inclusive that will explain both the particle and wave properties of light. But for our purposes we may continue to think of light as waves from space.

Newton's experiments with the solar spectrum marked the beginning of the science of spectroscopy. When he passed the beam of sunlight from the hole in his landlady's window shutter through a glass prism, the band of color on the wall was correctly interpreted by him. But his *modus operandi* failed to display something that his successors found upon further experiment. Thin dark lines were noticed crossing the color bands, and it was many years before anyone understood the true nature of them.

Joseph Fraunhofer studied these dark lines carefully and listed the ones he could

discover with the instruments available in his day. And in recognition of his work we call them Fraunhofer lines even today. But Kirchhoff should have his name linked with them, for it was he who explained them first. He learned from his laboratory experiments that each element, when excited to shine by heat or electricity, displayed characteristic lines in its spectrum. He concluded that the lines in the solar spectrum indicated the gases in the solar atmosphere. Thus the spectrum gives us a means of analyzing a body 93 million miles away, just as in the laboratory the spectroscopist analyzes the component materials in a piece of brass. Helmholtz, one of our great physicists of the past, said, "It has excited the admiration and stimulated the fancy of men as hardly any other discovery has done, because it has permitted our insight into worlds that seemed forever veiled to us."

Then this magic wand was extended to touch the planets, the stars, the nebulae, and the galaxies. Wherever a beam of light was received, an analysis could be made. Waves from space carried messages to us down the telescope tube. After more than a century of solar and stellar analysis we have not finished. Only last year the chemical element *thulium* was found in the solar atmosphere.



The spaces between the stars contain matter, too, as revealed by stellar spectra. In these Mt. Wilson spectra the sharp lines of interstellar sodium are weak for the nearby star (*top*), and strong for the distant one (*bottom*).

"Coronium" was a hypothetical element found by the spectroscope in the corona that is seen surrounding the sun during a total eclipse. Known only by its spectral lines, it was a mystery. That, too, was cleared up last year, by the work of Edlén. It is believed to be ionized iron, calcium, and nickel. This same discovery led to new ideas about the temperature in the atmosphere of the sun, which may now run up to a million degrees centigrade.

Not only has the spectrum offered a means of analyzing stars out in the depths of space, but it has played its role also in studying the infinitesimal. With the Newtonian "rainbow" we explore the universe and the atom alike.

The reckless schoolboy, you remember, questioned his professor's assertion that the atom was not subject to analysis. "But suppose someday they do divide it?" he asked. "Ridiculous," was the answer, "the word itself comes from the Greek, and means indivisible." Yet today the atom itself is pictured as a solar system. Sir Ernest Rutherford, who discovered the nucleus of the atom, suggested this planetary picture of electrons whizzing around the nucleus.

But there were practical objections to so simple a structure. If this were correct, the radiation (light or waves) sent out by such atoms would mean their destruction. The "planetary" electron would fall into the "solar" nucleus, and that atom would cease to exist.

Then the spectroscope came into play. Glowing hydrogen gas gives off a bright-line spectrum composed of a red, a blue, and two violet lines, and some lines of higher frequency. These lines are more exactly described by their frequencies, that is, the number of vibrations per second, or by their wave lengths, which is another way of measuring waves. Within our memories radio broadcasts have used both wave length and frequency as a tuning scale. Nearly 60 years ago, the wave lengths of these principal lines of hydrogen had been measured, and two of them bear letters assigned by Fraunhofer back in 1814:

(C)	Red line........	$H\alpha$	6562 angstroms
(F)	Blue line........	$H\beta$	4861
	Violet line........	$H\gamma$	4340
	Violet line........	$H\delta$	4101

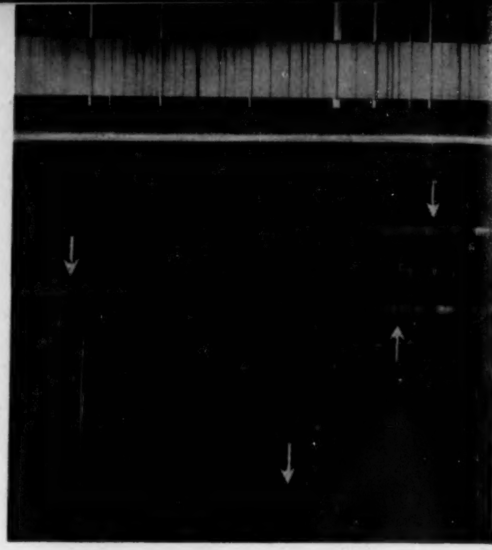
A Swiss mathematician, J. J. Balmer, wondered if there were any relation between these numbers. He adopted what he thought to be the shortest possible wave length, 3645.6, compared it with these hydrogen lines, and found a series of simple fractions:

$$\frac{6562}{3645.6} = \frac{9}{5} \qquad \frac{4340}{3645.6} = \frac{25}{21}$$

$$\frac{4861}{3645.6} = \frac{16}{12} \qquad \frac{4101}{3645.6} = \frac{36}{32}$$

From these fractions, 9/5, 16/12, 25/21, 36/32, you will note as Balmer did that the numerators are all squares ($9 = 3x3$, $16 = 4x4$, and so on) and the denominators are each 4 less than the numerators. Of course, this sounds like hocus-pocus (like Bode's law), but here was something that made sense to this schoolteacher.

It was on Balmer's discovery of this comparatively simple mathematical relation that the work of Niels Bohr rests. His conception of the atom was like Rutherford's, electrons (planets) whizzing around the nucleus (sun). Bohr had his planets jump their orbits with the sending out of energy in lumps, so to speak—quanta. And each jump released energy—light waves. The jumps were guided by the numerology that Balmer discovered. The energy levels were always the same and the wave lengths were always the same. Therefore hydrogen always gives off its energy in the lumps mentioned as $H\alpha$, $H\beta$, $H\gamma$, $H\delta$. Those lines in the spectrum are then the fingerprints of the element. And so it is for each element. We can recognize it whether it is in the flame on the laboratory table or in a distant nebula, shining under unusual conditions.



A star's motion toward or away from us is measured by shifts in the positions of its spectral lines. At top, note the displacement of stellar iron lines compared with their normal laboratory positions. At bottom are many (objective-prism) spectra, in which case the reference line produced by a neodymium-chloride filter is indicated by the arrows.

Just as there were maps of the sky before there were maps of the earth, the spectrum of the sun was studied before spectra in the laboratory. Astronomy, unlike charity, does not always begin at home.

MEXICAN CONFERENCE

Upholding the spirit of the Americas, and displaying their customary regard for the continuity of scientific reseach notwithstanding worldwide war, more than two-score astronomers, physicists, and geologists, from both North and South America, will participate in the Inter-American Scientific Conference in Mexico, February 15-26, on the occasion of the dedication of that country's new National Astrophysical Observatory (see *Sky and Telescope*, December, 1941).

President Manuel Avila Camacho, of Mexico, in his invitation to the scientists, said: "The purpose of the Mexican Government is to contribute to the maintenance, in the American continent, of the progress of science and culture, and thus counteract as much as possible the paralyzation of scientific and cultural activities in the countries devastated by war."

Among the leading Mexican scientists participating in the conference are: Prof. Luis Enrique Erro and Dr. Carlos Graef, director and assistant director of the new National Observatory, Dr. Monges-Lopez, dean of the faculty of sciences of the National University of Mexico, Prof. Manuel S. Vallarta, of Massachusetts Institute of Technology, Dr. Joaquin Gallo, director of the National Observatory at Tacubaya, and Dr. Alfredo Banos, Jr., head of the National University physics department.

Nearly the entire field of modern astronomy and geophysics will be covered by the papers to be presented at the various conference sessions, the subjects of which are: The interstellar medium, the classification of stellar spectra, problems of the galaxy, variable stars, time and change, cosmic radiation, and geophysical problems.

AMERICAN ASTRONOMERS REPORT

The Editors review some papers presented at the 67th meeting of the American Astronomical Society. Complete abstracts will appear, as usual, in the Publications of the Society and elsewhere. For a general story of the meeting, *see page 14.*

100,000 Star Spectra

A VOLUME of 100,000 stellar spectra will be a memorial to Annie Jump Cannon, famous woman astronomer, who died last year. Mrs. Margaret W. Mayall, of Harvard College Observatory, reported that all the unpublished spectral classifications which were determined by Miss Cannon will appear as a volume of the Harvard *Annals,* made possible through the kindness of Prof. James R. Jewett.

The spectra will be marked on photographic prints, which will be reproduced in a form similar to the Henry Draper Charts in the Harvard Tercentenary Volume (*H. A. 105,3*).

During her lifetime, Miss Cannon originated the modern system of classification of the spectra of stars, and published the *Henry Draper Catalogue,* containing 215,300 stars, and the *Henry Draper Extension,* of about 50,000 stars. The total of all these, including the new volume, is therefore about 365,000, a record of astronomical proportions even among astronomers.

Interstellar Dust and Atoms

CLOUDS of interstellar dust are at the same time clouds of atoms, according to Dr. Lyman Spitzer, Jr., of Yale University. His paper described studies of emission and absorption lines in stellar spectra and various regions of the sky, from which it appears that emission lines as well as absorption lines originate in the scattered clouds of dust and atoms. This indicates that galactic hydrogen is largely ionized everywhere in the galaxy except in the densest, most nearly opaque absorbing clouds, and suggests that there may be a galactic excess of ultraviolet hydrogen-ionizing radiation of the same sort known to exist in the spectrum of the sun. The dust and atoms of space occur together in clouds roughly 100 parsecs in diameter and widely scattered through space, but imbedded in a substratum of low, but uniform, density, as pointed out by F. H. Seares some time ago.

Photoelectric Studies

U OPHIUCHI, AR Aurigae, and VW Cephei are eclipsing stars studied by Dr. C. M. Huffer with the photoelectric photometer of the Washburn Observatory. Some of his results show that U Ophiuchi is composed of two nearly equal ellipsoidal stars, partially eclipsing each other, and the brighter star being smaller, more massive, and denser than the fainter star. The results agree with those of J. S. Plaskett, except that the solution definitely shows uniformly illuminated disks.

The eclipses of AR Aurigae are total at primary and annular at secondary, and the stars are uniformly illuminated spheres. This solution differs from Dr. J. J. Nassau's, which gave partial eclipses. However, only minor differences in sizes, masses, and densities result.

VW Cephei is composed of ellipsoidal stars with very shallow eclipses. The period, 0.27832216 days, is slightly longer than those previously published for this star.

Blue and Red Magnitudes

DR. J. J. NASSAU, of Warner and Swasey Observatory, and Dr. J. A. Hynek, of Perkins Observatory, collaborated in the study of the magnitudes and colors in Selected Area 108 and in the globular cluster Messier 12, which is situated three degrees from the Selected Area studied.

The essential features of the blue and red color-magnitude diagram of the stars in the cluster are:

1. Total absence of early-type supergiants.
2. The presence of very few stars in the region ordinarily occupied by cluster-type (short period) variables.
3. An abundance of red supergiants together with a total absence of red giants.
4. The presence of essentially two groups of stars, one of early spectral class of constant absolute magnitude, and the other of late spectral classes with absolute luminosity increasing with the red index.

"Twin" Contact Binaries

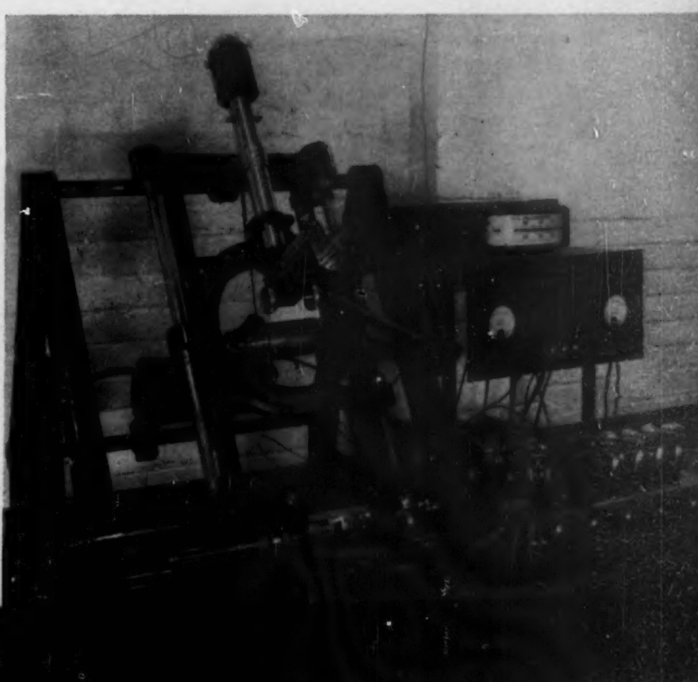
A HUNT for eclipsing double stars which are equal in size, mass, and brightness, and have their photospheres just in contact, has been carried on by Dr. B. W. Sitterly, of Van Vleck Observatory. He has computed theoretical light curves for such stars under certain conditions, and then looked for stars with light curves exhibiting the sharply bowed maxima indicative of the pronounced deformation from spherical shape which stars close together must undergo.

In five cases studied by Dr. Sitterly, that of OO Aquilae indicates that it is a typical "twin" contact binary, whereas, the components of RZ Tauri are not quite in contact and those of RR Centauri overlap considerably. Two other systems, U Pegasi and VW Cephei, have primary and secondary minima definitely unequal, but their curves indicate that their components are equal in mass and size but have a ratio of three to two in their light.

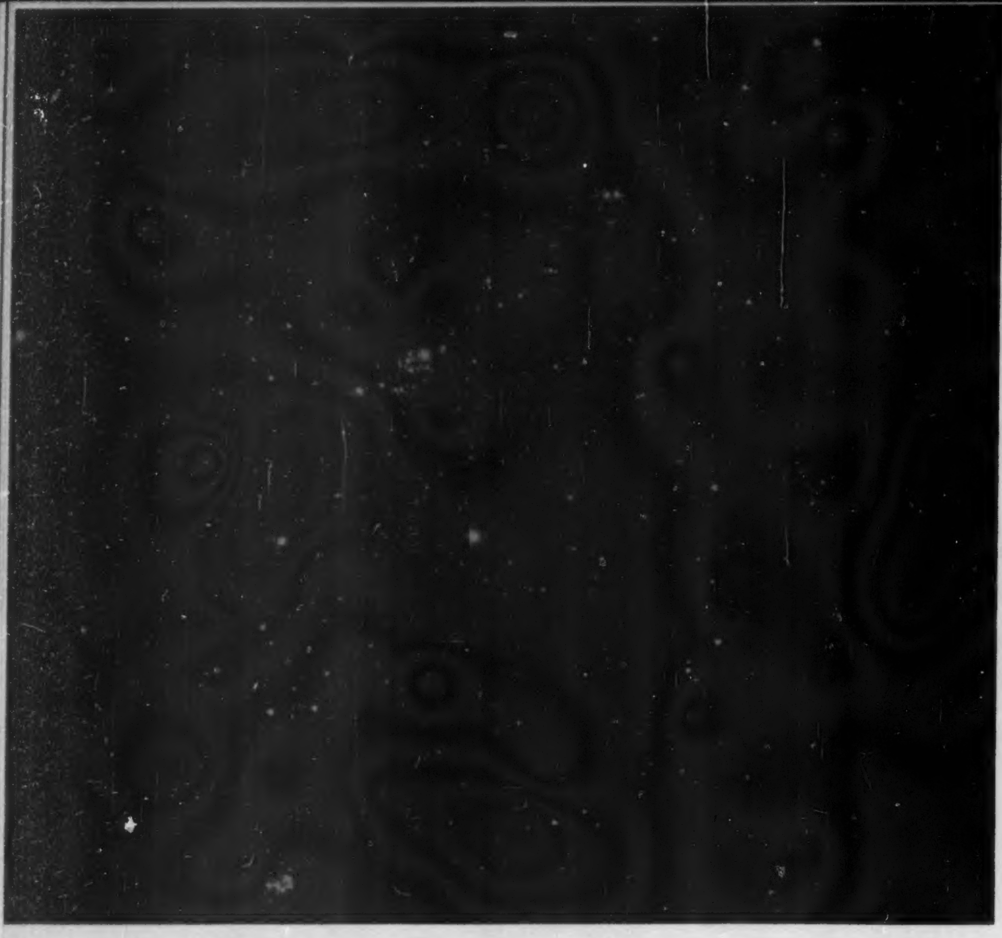
Star-Counting Device

ALREADY used on the first part of an extensive star counting program in the Orion region, a photoelectric-photometer star-counting device was described and exhibited by Dr. S. W. McCuskey, of the Warner and Swasey Observatory. Counts of stars brighter than magnitudes 12, 13, 14, and 15, in 15 Selected Areas of the anti-center region of the galaxy, have shown a rate of counting, including the necessary calibration and setting, of about 2,000 stars per hour. A run over a given area of a plate results directly in the numbers of stars brighter than four arbitrarily chosen magnitude intervals.

When all phases are considered, the gain in time due to the use of this machine amounts to a factor of two. The fatigue on the observer is much less than for ordinary visual counting, although it is still necessary to place each star image in the sensitive beam of the photometer. Thus far completely automatic scanning has not yielded results accurate enough for statistical purposes.



The photoelectric star counter of Warner and Swasey Observatory. With this instrument, stars of four different limiting magnitudes can be simultaneously counted, at the rate of 2,000 an hour. Engraving, courtesy Warner and Swasey Observatory.



Just after dark on February evenings Algol shines nearly overhead in north temperate latitudes. In this 2-hour exposure of the Algol region, made with a 1½-inch Ross lens of 6-inch focal length, the Demon Star is just below the center; Algenib (Alpha Persei) above the center; Cassiopeia in upper right corner, and left and below it the Double Cluster. Capella is on the left margin, while the Pleiades are near the bottom edge. Harvard Observatory photo (contact print).

The Story of Algol

By Zdenek Kopal

Harvard College Observatory

THE variable star β Persei, or Algol, as it is more commonly called, belongs certainly among the most remarkable stars visible with the naked eye; a Gallup poll among amateurs and professional astronomers alike would undoubtedly confirm this. Its very name (*El Ghoul* in old Arabic, meaning literally *changing spirit*) suggests that something unusual about its appearance may have been known to the ancient world. That this star appears sometimes fainter than its normal brightness was known to astronomers long ago. Montanari noticed it unmistakably as early as 1670, and was so impressed by this curious phenomenon as to publish a special pamphlet about it. About 20 years later, Maraldi, another Italian astronomer, could only verify his experience.

But the discovery that the variation of Algol's brightness *repeats itself periodically* did not follow until nearly a century later, and is due to John Goodricke. Goodricke, then a youngster of 19, communicated his discovery to the Royal Society in London early in 1783. He found that the successive minima of Algol occurred at intervals of about 2 days, 20¾ hours—a value which differs from the modern period by only four minutes[1]—and that the descent to and recovery from minimum took about eight or nine hours; for the rest of the cycle the light remained sensibly constant. And in the conclusion of his memoir we read the following statement which has truly become historic: "If it were not perhaps too early to hazard even a conjecture on the cause of this variation, I should imagine it could hardly be accounted for otherwise than . . . *by the interposition of a large body revolving around Algol.* (Italics ours.)

His boldness can be fully appreciated if we realize that this was written 20 years before Sir William Herschel demonstrated the existence of any physical binary stars. No wonder, therefore, that the gentlemen of the Royal Society were incredulous, and asked Herschel, then at the beginning of his career, to verify Goodricke's discovery. The great astronomer did so at once; and the introductory sentences of his "Observations upon Algol" (read before the Royal Society on May 8, 1783) reflect his fresh impressions. "The most extraordinary Phenomenon of the occultation of Algol is so interesting a subject, that we cannot too soon collect every observation that may serve to ascertain its period, or assist us to find what quantity of light the star loses on these occasions. *The wonderful train of consequences that may be drawn from such regular occultations engage our utmost attention,"* (italics ours) were his prophetic words. As to Goodricke's hypothesis of "a large body revolving around Algol" Herschel seemed, however, noncommittal. "The idea of a small Sun revolving around a large opake body has also been mentioned in the list of such conjectures," was all he had to say at this opportunity.

It seldom happens in the annals of science that the first guess of a discoverer in a far-reaching matter proves more fortunate than it did to Goodricke. Providence was kind to this precocious youngster, who within his short life (he died at 21) found time enough to discover, apart from Algol, the variability of β Lyrae and δ Cephei, and to have the Copley medal bestowed upon him by the Royal Society in recognition of his brilliant discoveries.

Not only had Goodricke's suggestion that Algol was an eclipsing binary been found true, but it was also confirmed later that the body revolving around Algol was actually larger than the bright star itself. For it could have been smaller, and the resulting light changes would differ but little from the observed ones—less than Goodricke could have detected. Yet this all was not obvious in Goodricke's day, and the binary hypothesis itself had to await its confirmation a further 100 years. It was not until 1889 that Vogel, in Potsdam, by means of the spectroscope recognized Algol as a binary system, and found that the bright star receded from us before the maximum eclipse and approached after it. When this became known, the binary nature of Algol was no longer in doubt.

"The wonderful train of consequences" —to speak with Herschel—which may be drawn from the light changes of Algol and similar eclipsing variables has been followed up by many investigators beginning with Edward C. Pickering, and culminated in the well-known researches by Russell and Shapley 30 years ago. The light curve of Algol is known with a high degree of accuracy. Algol was the first variable to be observed with the selenium cell and later with photoelectric apparatus. An analysis of such light curves has shown that the component undergoing eclipse at the time of the deep minimum is the smaller of the two—as Goodricke had rightly surmised—and its radius is about one fifth the radius of the orbit; the radius

[1] A year later Goodricke revised his original period to 2d 20h 49m 8s—a result on which modern observations have little to improve.

of the companion being larger by about 15 per cent. Both components revolve around the common center of gravity in circular orbits slightly inclined to the line of sight, so that at each conjunction one star passes in front of the other. The resulting eclipses are partial; at mid-primary-minimum about 70 per cent of light of the bright star disappears behind the disk of the companion.

Modern precise observations have revealed another minimum, half a revolution later, due to the eclipse of the dark star by the bright one. In contrast to the primary minimum, which is over a magnitude deep, this secondary minimum amounts to only a few hundredths of a magnitude. This indicates that the surface brightness of the companion must be very small compared with that of the bright star. Further, the measurements of color have revealed that at the time of primary minimum, when the companion is in front, Algol appears considerably redder than in full light. From this we conclude that the bright component is (in ordinary light) about 10 times as luminous as its mate, and that the latter must be a relatively cool star with radiation probably similar to sunlight. *The companion is therefore by no means completely dark.* If it could be seen alone, it would appear as a yellowish star of approximately 5th magnitude, still well visible with the naked eye.

An analysis of light curves can yield only *relative* dimensions of each particular eclipsing system, expressed in terms of the orbital radius taken as unity. In order to obtain the absolute dimensions and masses of the components, photometric data have to be supplemented by spectroscopic observations of both components. And here we meet our first outstanding difficulty. *Neither Vogel nor anybody else has ever succeeded in detecting the lines of the secondary component of the Algol system.* This should perhaps not be so surprising; for we have learned that in ordinary light the components differ nearly three magnitudes in brightness, and experience has shown that a difference of one magnitude is sufficient to extinguish completely all traces of the lines of the faint star from a combined spectrum. Algol behaves therefore like a typical single-spectrum binary; but such being the case, the whole message it sends us along the rays of light cannot be deciphered, and tells us nothing really definite about the absolute dimensions of this system. Should we give up? There is always time enough for that.

Astronomers have realized that this difficulty could be circumvented if at least the radius of one component could be expressed in absolute units by some independent method. This can indeed be accomplished by the study of the so-called "rotational effect." The reader should have no difficulty in visualizing that if a star is rotating, one edge is coming toward us while the other is going away. Now if this star happens to be one component of an eclipsing binary, and the other star passes in front of it, a moment will come when only a crescent on one side, and later on the other side, remains visible. We can measure speeds with which such crescents are moving toward us or away from us because of rotation, by means of the Doppler effect, which shifts the positions of the lines in their spectra, and so we obtain the velocity of rotation at the equator in kilometers per second. If finally we assume the rotation and revolution are of equal periods (which is probably true for close pairs), the radius of the rotating star, in absolute units, follows without difficulty.

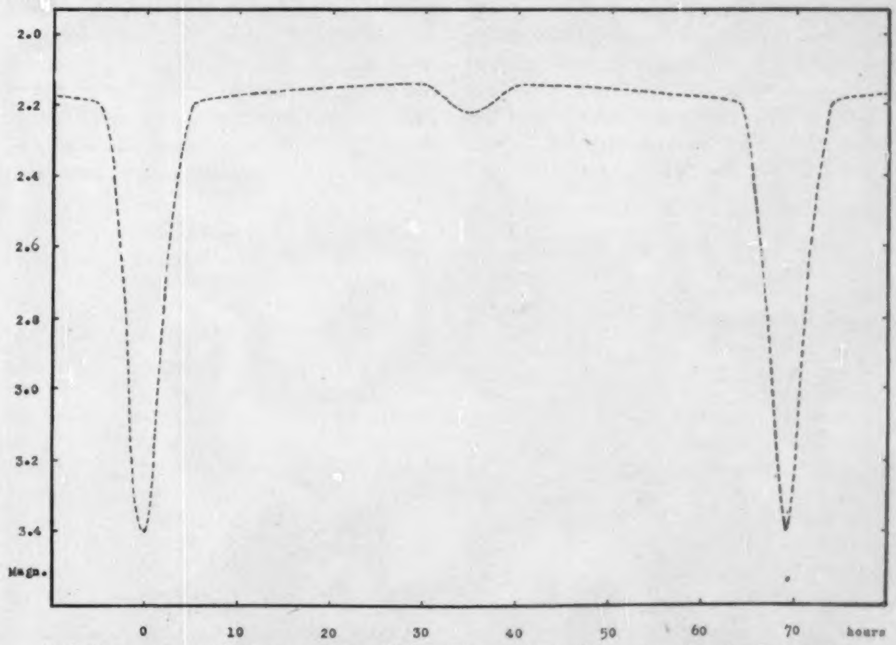
The most exhaustive study so far of the rotational effect in Algol was carried out by D. B. McLaughlin, of Ann Arbor Observatory, during the past decade. The measurements were delicate to make, and the results are not yet as accurate as we would wish to have them. At present, the most probable absolute dimensions and masses of components of the Algol system are as follows (the sun's mass and radius taken as units):

Bright star: Radius=3.1 Mass=4.7
Companion: Radius=3.7 Mass=0.95

The spectrum of the bright component has been classified as *B*8, which characterizes moderately massive white stars of an effective temperature of about 12,000 degrees. The spectrum of the companion has never been seen; but judging from its surface brightness, the effective temperature of the companion cannot well exceed some 6,000 degrees. The radius of the relative orbit is about 11,200,000 kilometers, which is about one fifth of the distance of Mercury from the sun. The distance of Algol from us is within the reach of celestial triangulation, and amounts to nearly 100 light-years. The apparent separation of the two components at maximum elongation is therefore only about 0".0024. No wonder, then, that Sir William Herschel saw Algol "distinctly single" in the focus of his 7-foot telescope! The above figures present no unusual feature, and "so it all ends happily," concludes Sir Arthur Eddington in his delightful story of Algol in *Stars and Atoms*. That was written 15 years ago. I wish we could share his optimism today.

As it often happens, once a problem has been cleared up, Nature has new ones for us in store. So at the beginning of our century, A. A. Belopolsky, of Poulkovo Observatory, discovered that Algol is not traveling through space alone. Belopolsky found that the radial velocity of the center of mass of the eclipsing system was not constant. It increased and decreased steadily in a period just under two years. This was not difficult to explain: the center of mass of the eclipsing system was describing an elliptical orbit. Obviously, there must be something for it to move around, and this can be only another star. Spectroscopic messages pertaining to it are, unfortunately, again incomplete and cannot be deciphered as they stand.

If, in the case of the eclipsing system, the "missing word" was the mass-ratio of the two components, for the third body the unknown quantity is *the inclination of its orbital plane to the line of sight.* With the former "missing word" happily replaced by the interpretation of the rotational effect, a knowledge of the inclination of the third orbit would give us a clue to its absolute dimensions. Spectroscopic observations show that the semi-



A light curve of Algol in ordinary light. The reader will notice that the brightness between minima is not entirely constant, but increases slightly toward the secondary minimum, and decreases later. The variation is due to the parasitic light "reflected" by the surface of the companion, which, illuminated by its brilliant mate, exhibits phases like the moon's.

major axis of the third orbit must be larger than the distance sun-earth. At the distance of Algol, one astronomical unit would appear as an angle of 0".033. A quantity of this order of magnitude is not so small that modern observations could not detect it. Alden, in measuring the position of Algol on photographs taken with the long-focus refractor at Allegheny Observatory, found that it indeed oscillated in a period indicated by spectroscopic observations.

The third body in the Algol system proved therefore to be another invisible star whose existence is regularly recognized; and if observations were accurate enough, they could reveal the required inclination of this star's orbit, and so give us a clue to its absolute dimensions. The reality turned out, however, rather tantalizing. The quantities to be measured were too small. On the whole, Alden's results brought hardly more than a qualitative confirmation of the existence of the third body. A repetition of Alden's work, based on a larger number of plates, is now in progress at Sproul and Allegheny Observatories. These investigations may possibly tell us something more as to the "missing word" of our present problems; but so far we are left guessing.

If, for instance, the third body revolves in the same plane as the eclipsing pair, then the spectroscopic evidence requires that it must possess a mass 1.1 that of the sun, and its distance from the eclipsing pair must amount to about 500,000,000 kilometers. If, however, the plane of the third orbit deviates considerably from that of the eclipsing system, both the mass of the third body and the semi-major axis of its orbit will be increased. But in all probability, regardless of the uncertainty in orbital inclination, the mass of the third body only slightly exceeds the mass of the companion in the eclipsing pair, and is probably close to that of the sun.

Therefore, both the companion and the distant third body should resemble the sun in luminosity and color, and the idea suggests itself that accurate colorimetric measurements could possibly demonstrate the presence of the third body too. The color of Algol in full light should be predominantly blue, for most light then comes to us from the bright star of spectral class *B8*. Algol should, however, not appear as blue as other stars of this spectral type, because the companion, whose radiation must be similar to sunlight, should produce an admixture of yellow in the combined light. However, the relative luminosity of the companion being known, the color of the combined light can still be predicted. A coloring *in excess of* the contribution of the companion should then represent the third body.

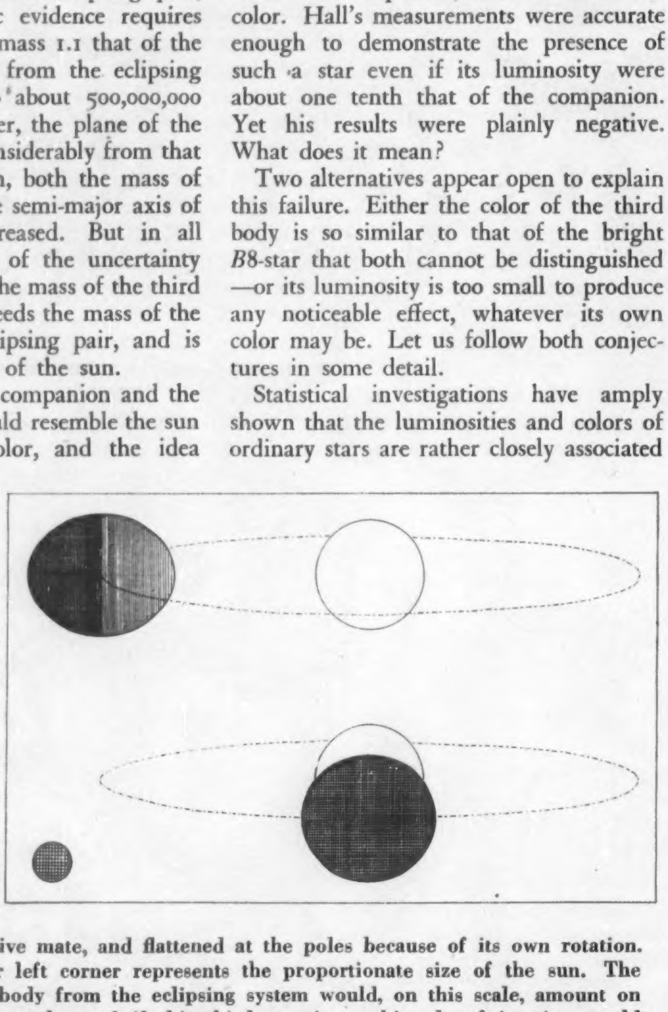
Quite recently, John S. Hall, at Sproul and Amherst Observatories, set out to search for such an effect by means of precise photoelectric apparatus. His careful investigation, extending from the violet to deep infrared, resulted in a surprise. Hall found that *the color of Algol can be satisfactorily predicted from known data only if we assume that the third body is completely dark*. Observations revealed no trace of any further admixture of color than could be accounted for by the companion. But the third body cannot be completely dark. Its mass indicates that it should in fact be somewhat brighter than the companion, and of a similar color. Hall's measurements were accurate enough to demonstrate the presence of such a star even if its luminosity were about one tenth that of the companion. Yet his results were plainly negative. What does it mean?

Two alternatives appear open to explain this failure. Either the color of the third body is so similar to that of the bright *B*8-star that both cannot be distinguished —or its luminosity is too small to produce any noticeable effect, whatever its own color may be. Let us follow both conjectures in some detail.

Statistical investigations have amply shown that the luminosities and colors of ordinary stars are rather closely associated with their masses. If a star is to have a color similar to that of a *B*8-star, its mass must be appreciably greater than that of the sun. In the case of Algol, it is indeed possible to increase the mass of the third body sufficiently if we assume that its orbital plane is nearly perpendicular to the line of sight. But then we run into an unexpected difficulty: namely, the relative orbit of the third body becomes so large that the apparent separation of the eclipsing pair and the third body could exceed 0".2, and thus exhibit a nice visual binary with components differing only about one magnitude in brightness. Such a binary could possibly have escaped Herschel, but not a Burnham or an Aitken using the Lick or Yerkes refractors. The fact that Algol has never been seen double excludes, therefore, the possibility that the third body could be as massive as to match the *B*8-component in color.[2] Stars with smaller masses are as a rule yellow or red; but the third body cannot be such without conflicting with Hall's observational evidence unless its luminosity is but a small fraction of that of the companion. But this is again at variance with the mass of the third body, which is actually larger than the mass of the companion. So by elimination of alternative hypotheses we are led to the conclusion that *the third body of the Algol system must be a star of mass approximately that of the sun, but blue-white in color, or of minute luminosity* (possibly both). Obviously, this cannot be an ordinary star; but stars of such properties are also not entirely unknown. In fact, they seem to be pretty common. Astronomers call them white dwarfs. A choice of a white dwarf for the third body of the Algol system would thus kill two birds with one stone. It would make the star white, but at the same time too faint to be noticeable otherwise than by its gravitational attraction.

This is where our story of Algol now ends. If the above reasoning proves correct, the third body in the Algol system would join the long series of "invisible" stars, beginning with the companion of Sirius, which turned out to be white dwarfs. For the present, however, it may be wise to retain still some reserve in accepting this picture. In particular, we should await further information which astronomers may yet be able to obtain on the "missing words" of our problem. It may still become possible from measurements of long-focus photographs to infer with some degree of accuracy the inclination of the third orbit, and so the absolute dimensions and mass of the third body. Or we may ultimately succeed in observing the spectrum of the companion which eclipses the *B*8 star at the times of deep

(*Continued on page 23*)



A model of the eclipsing system of Algol, as it would appear perspectively to a terrestrial observer, at the greatest elongation (top) and at the time of the deep minimum (bottom). Note that the bright star is practically spherical; but the companion is appreciably elongated on account of the powerful tidal action of its five times as massive mate, and flattened at the poles because of its own rotation. A circle in the lower left corner represents the proportionate size of the sun. The distance of the third body from the eclipsing system would, on this scale, amount on the average to a few yards; and if this third star is a white dwarf its size would correspond to a tiny speck of dust.

[2]A complete absence of lines of the third body in the combined spectrum of Algol provides an additional reason. None of the spectral characteristics exhibited during minimum light can be ascribed with certainty to any component other than the primary star.

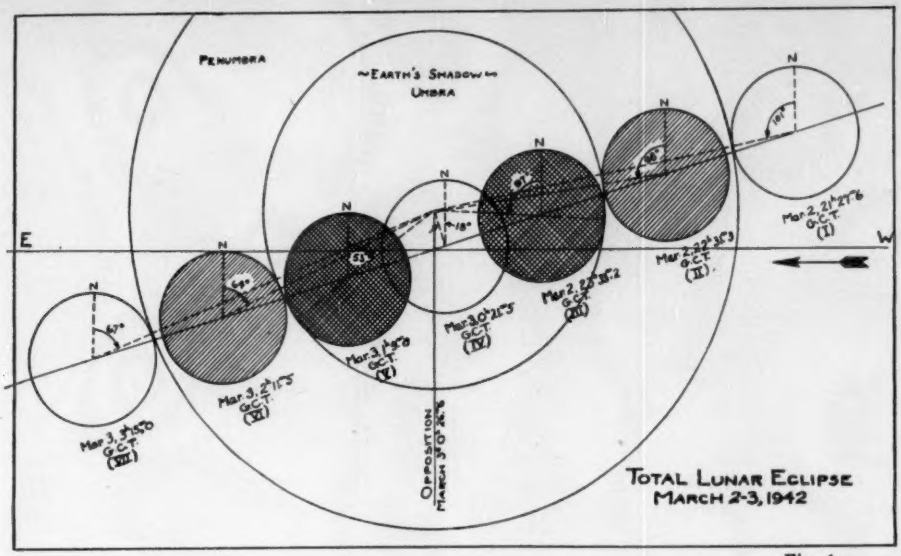


Fig. 1.

Shadow on Moon in March

By Sylvan Harris

OBSERVERS at New York, or, for that matter, anywhere in the United States, will not see the beginning of the total lunar eclipse of March 2-3, 1942. New Yorkers will, however, view the moon somewhat before total immersion in the umbra, so they will see the total phase and through to the end of the eclipse.

At the instant of the middle of the eclipse the moon will be in the zenith 2° 20′ west of Greenwich. If a person were situated in that longitude, and if the earth were to stop rotating on its axis but continue along its orbit, and the moon likewise continued on its orbit, he would see the picture represented by Figure 1, which is a "projection" of the eclipse upon the celestial sphere.

The moon would be seen to travel southeast in the sky, first touching the penumbra on the western side at 4:28 p.m. E.S.T., and leaving the penumbra finally on the eastern side, at 10:15 p.m. The schedule of events will be as follows:

			Greenwich Civil Time h	m	E. S. T. March 2
I.	First penumbral contact	March 2	21	27.6	4:27.6 p.m.
II.	First umbral contact	"	22	31.3	5:31.3
III.	Beginning of totality	"	23	33.2	6:33.2
IV.	Middle of eclipse	March 3	0	21.5	7:21.5
V.	End of totality	"	1	9.8	8:09.8
VI.	Last umbral contact	"	2	11.5	9:11.5
VII.	Last penumbral contact	"	3	15.0	10:15.0

The first two phases will not be seen from the United States, as mentioned heretofore. At New York, moonrise on March 2nd will occur at 5:41 p.m. E.S.T., which is 10 minutes after the first umbral contact. When the moon rises, therefore, it will have been completely immersed in the penumbra and will be partly into the umbra, as in Figure 2.

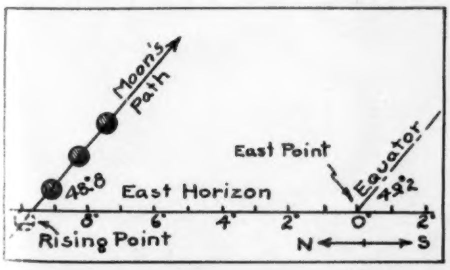


Fig. 2.

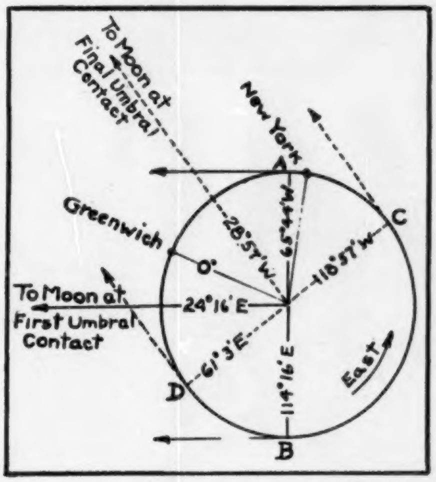


Fig. 3.

Figure 3 shows why the beginning of the eclipse will not be visible from New York. At the moment of first umbral contact the moon will be in the zenith at longitude 24° 16′ east of Greenwich. Because the moon is near the equator, we may draw lines tangent to the earth (represented by the circle in Figure 3) and parallel to the line to the moon. Then the points *A* and *B* are the extreme eastern and western longitudes of the earth from which the first umbral contact will be visible. In other words, observers between *A* and *B* will see first umbral contact.

Notice that New York is somewhat west of point *A*, so New Yorkers would have to travel eastward on the Atlantic Ocean about 530 miles to see umbral contact.

Similarly, when the moon leaves the umbra finally, it is on the meridian in longitude 28° 57′ west of Greenwich, and observers between points *C* and *D* will see this event. The conditions are:

First umbral contact { visible over *BDA*; not visible *ACB*

Final umbral contact { visible over *DAC*; not visible *CBD*

Neither contact is visible from *C* to *B*.

The longitudes shown in Figure 3 are approximate, because no account has been taken of the moon's semidiameter, atmospheric refraction, or the moon's latitude.

As shown in Figure 4, the moon will rise at a point on the eastern horizon about 10 degrees north of the east point for New York observers. It will move southwest at an angle of 48°.8 with the horizon.

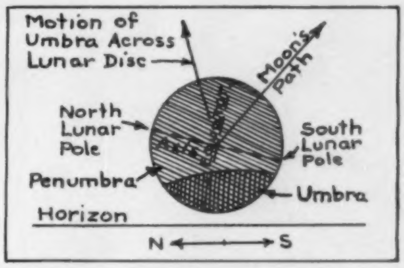


Fig. 4.

From Figure 1 we can determine exactly at what points of the moon the shadows make contact. For example, referring to phase I, the point where the broken line from the center of the moon to the center of the umbra cuts the circle of the penumbra gives the point on the moon where the penumbral contact is made. In Figure 5, which represents the moon, this point of contact is marked by the Roman numeral I. The points of the other contacts are marked similarly. It will be noticed that the moon's axis does not point directly north and south, but has an average position angle of 24°.4 to the east during the eclipse. The adjacent craters of the moon are numbered:

1. Cardanus
2. Krafft
3. Riccioli
4. Grimaldi
5. Appolonius
6. Maclaurin
7. Vendelinus
8. Petavius

Observers in the western portions of the United States will see only the late phases of the eclipse, as the longitudes in Figure 3 show.

Note: All drawings have been made erect; for an inverting telescope they should be considered reversed.

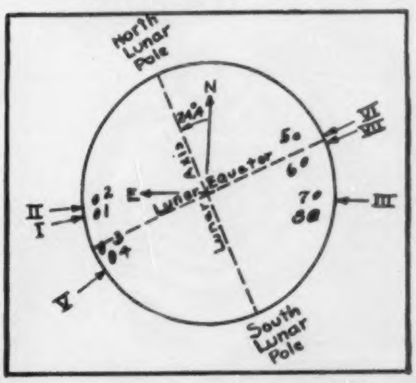


Fig. 5.

SUMMARY OF A LECTURE

before the Junior Astronomy Club

By Bart J. Bok

Harvard College Observatory

ON November 22nd I was asked by the Junior Astronomy Club of New York to address the group on the relation between science and astrology. Since it happened that several astrologers were present at this meeting, I am taking this opportunity to record here some of the points that I brought out in the lecture, especially those on the attitude of scientists toward astrology as it is practiced today.

There were three reasons why the committee of the American Association of Scientific Workers for the study of astrology issued in February, 1941, the report that was published in The SKY, and **The Scientific Monthly.** The first reason was that the group wished to emphasize the need of combatting the pure racketeering aspects of present-day astrology; the second, that it felt that it was desirable for a group of scientists to state clearly why they had no faith in astrological predictions of any sort. The final reason was that the group wished to call to public attention the fact that not a single astronomer, who is actively doing scientific research, has any faith in the predictions of astrology. In fact the public should know that astronomers are unanimous in their condemnation of astrology, whatever the astrologers may say to the contrary.

One does not need to go far before one runs into the type of astrology that is solely practiced for the purpose of getting nickels and dimes out of the pockets of the unsuspecting public. Those astrologers who consider themselves the leaders in their profession are almost unanimous in agreeing that the preparation of reliable astrological predictions is a time-consuming affair which apparently requires great care. And yet many of them have, either through direct cooperation or by silently standing by, encouraged the sale of astrological advice that is worthless by any standards, even those set by the astrologers themselves.

Astrology should not be tolerated as a cheap aid to salesmanship and advertising, and newspapers of good repute should not print daily columns of mushy astrological advice. Several astrologers have professed to me their interest in eliminating the racketeering aspects of astrology that only too obviously exist today, but so far little has happened.

In attacking astrology the main charge made by scientists has been that astrologers have failed to provide a sound basis for their pseudo-science. As a scientist who has spent considerable time on the study of astrology, I see it as an arbitrary set of rules, based in part on superstitions, for the origin of which one has to go back to ancient Babylon, and for the rest, on a prejudiced selective interpretation of those experiences that tend to confirm the same old set of rules. I am therefore hardly surprised to find that astrologers have been unable to furnish proofs of any sort for their tenets, but I must admit that I had expected that astrologers would be doing more to provide some sort of an experimental basis for their rules. **There does not exist today a fundamental body of data from the analysis of which follow the basic rules of astrology.**

In their correspondence with members of the A.A.S.W. committee, astrologers admit that so far very little effort has been made here in the United States to check the rules of astrology with the aid of statistical analysis. One astrologer who is by his colleagues considered one of the leaders in his field writes: "It is regrettably true that very little has been done by American astrologers in the way of published statistical proof of astrological principles."

A number of reasons have been given to me why such work has not been done. Some profess a disbelief in the effectiveness of statistical methods, which is a good proof of their ignorance of the subject. Others claim that astrology does not need to be examined because it is a FACT. To a scientist who is acquainted with the human tendency to remember successes and forget failures, this argument carries no weight; the only proofs that are acceptable are those that can be reproduced in black and white. I have also heard it said that astrology represents the only way by which man can be in tune with the cosmos. That is just so much bosh.

The most prevalent answer to our request for proof of the basic rules seems to be that astrologers do not have at their disposal the funds for research such as are available to the scientists in our educational institutions. However, somebody must get the money that the public pays daily for its astrological guidance. The astrologers who are apparently sincerely interested in carrying out tests are perhaps not of the money-making variety. But I am certain that, if there really did exist a sincere desire to carry out such tests, the necessary funds could be found.

The carrying out of conclusive tests will not be a simple matter. There are some types of tests that can be performed only by expert psychologists and since this is not my field of study I shall not consider them. It does seem, however, as though there are some tests which are perfectly straightforward and which should be carried out if the astrologers should ever wish to receive a hearing. Our great biographical volumes, such as **Who's Who** and **American Men of Science,** contain excellent source material gathered by persons who were not at all interested in proving or disproving the rules of astrology. Also, comparative study of the case histories of twins, or even better, study of the case histories of children of different mothers, born within a few minutes of each other at the same hospital, should be useful.

If such tests are to be carried out, astrologers will do well to take pains to present their results in such a form that there can be no doubt about the basic data and the techniques of analysis. For a statistical investigation, the best procedure would be for those who are to do the work to announce their program in print before the work is undertaken. **Statistical results can only be significant if those who publish them show proof that all the material is presented.** Astronomers and other scientists in whose fields statistical analysis plays a prominent role know how easy it is to obtain positive or negative conclusions as desired, if one uses the technique of publishing only the one test out of every 10 that most nearly coincides with the hoped-for results.

Several astrologers have asked me why scientists are not making more extensive studies of failures and successes of astrological predictions. As far as I am personally concerned, I have already spent a good deal of time on the study of techniques of preparing and interpreting horoscopes, but it seems a waste of time for me to make in the future extensive studies of astrology. That is decidedly a job for the astrologers, who have still to prove the worth of their product.

The role of the scientist should frankly be a critical one. He could serve in a way in an advisory capacity and head off the making of studies that would not really contribute anything in the form of tests. Second, it would be in part his job to analyze critically the results of statistical studies.

It is perhaps useful at this point that I summarize my reasons for my disbelief in astrology.

First, I fail to see anywhere in the known universe a physical cause that might work even remotely along the lines required to explain the effects which, astrologers claim, arise from the sun, moon, stars, and planets. It seems highly improbable to me that rather similar planets should exert entirely dissimilar effects. I can see no reason why the exact moment of birth—which in many cases can be advanced or retarded considerably by the action of a physician—should have any special significance.

Second, when I consider the historical development of astrology, I find there is good evidence that the foundation of astrology comes from the superstitious beliefs of primitive people. I can well understand why in the early days of our civilization people might, in their ignorance about celestial phenomena, turn to such beliefs, but I see no reason for us to continue to be primitives. There are many ancient cosmological ideas that were abandoned as science progressed.

Third, I would be ready to take astrology seriously if its rules appeared to represent a working hypothesis based on an extensive body of facts. As I have already mentioned, from a careful study of astrology and methods of casting horoscopes, I have found that such basic material apparently does not exist. Astrologers have asked why I use the concept of gravity, when its mechanism is perhaps in a way not fully understood, but reject the concepts of astrology. I consider gravity a useful working hypothesis because it interprets accurately a very extensive body of observational data on the

ASTRONOMICAL ANECDOTES

A MICHIGAN PHOTOGRAPH, AND "H. D."— "A HAMMER AND CHISEL MAN"

IN June of 1937, a magnificent job of multiple-point broadcasting was done on the occasion of the total eclipse of the sun observed from Canton Island. It seems, however, that in England they were having difficulty in hearing what was going on on the island, and I remember the late Prof. Alfred Fowler's ignoring of what the announcer was trying to tell him, and asking over and over again, "Where's Prof. Curtis? Let me speak to Prof. Curtis." He can speak with him now, for Prof. Heber Doust Curtis died on January 8th. He was not able to talk to Prof. Fowler that day, for instead of being on Canton Island for his 12th eclipse, he was in the University Hospital in Ann Arbor. Yet despite his age of 70 and his several periods of very poor health, his driving energy and elasticity make it very hard for me to believe he has died.

Dr. Curtis at first rebelled when I asked him to pose with the rest of the University of Michigan group of astronomers, on the deck of Commander Eugene McDonald's yacht *Mizpah,* in Chicago in 1930. The Ann Arbor group at a meeting of the American Astronomical Society is usually a large one; in earlier days it was even more so, for many American astronomers had at one time or another been in some way connected with what was called the "Detroit Observatory." Curtis on that occasion insisted that he had never set foot in the observatory as a student; despite his A.B. and A.M. degrees from Michigan, he had not been interested in astronomy. I insisted that he had been trained in Ann Arbor, and was an astronomer in 1930, so he should join the group. He did, at last, and was snapped, just three weeks before he arrived in Ann Arbor as the new director of the Observatories of the University of Michigan. He later spoke many times of my prescience on that occasion, for at the time he did not himself know that he was going to leave the University of Pittsburgh, where he had been director of the Allegheny Observatory for 10 years.

His early interests had been in the fields of the classics; one of his recent research papers was the restoration of an old fragment of an ephemeris of part of the year 467 A.D. (see the November, 1940, SKY). He was interested in all languages, and even dabbled a bit in the Mayan and Incan cultures, perhaps as a result of his having spent some years at the D. O. Mills station of the Lick Observatory, at Santiago, Chile. His sense of humor was delicious, and I remember his saying that the old civilizations had left such massive structures that we might speak of at least one culture as "the indelible Incas." His first teaching jobs in Michigan and California were in Greek and Latin; he often reminded me that he, too, "came out" during a depression (1893), and had to take the first high school job offered.

He went back to the East in 1900, and gained his Ph.D., this time in astronomy, at the University of Virginia in 1902. Then he went to the Lick Observatory, and from there to Pittsburgh. But this is not intended to be a recital of the man's career; I want to remember him and to recall him to others as a fine friend, apart from his indisputable reputation as a fine astronomer. One of my present colleagues, who knew him as a student at Virginia, summed it up rather well when he said, "Curtis was an all-around astronomer; many men knew certain specialized fields better than did Curtis, but he knew more about every field of astronomy than any other man."

At 3 or 4 a.m., the old Reo would come roaring around the back of the big dome, and the lonesome observer would know that it was "H.D." on his way down to "the Greek's" for a big breakfast, prior to returning to the observatory before dawn to start his session with the drawing board, designing Michigan's projected new observatory and the 96-inch reflector. How

Dr. Heber D. Curtis at New Haven, Conn., at the time of the solar eclipse of January 24, 1925—temperature, 2° F. This picture and others of Dr. Curtis appeared with an article about him, written by Dr. Keivin Burns, in The SKY, July, 1941.

he loved machine work, and designing of instruments! He insisted that he was "just a hammer and chisel man," but he was very right in insisting that pretty appearance of a machine which performed only passably was not as suitable as a huge hunk of iron and brass, with no streamlining, which turned out a crackerjack job of work. He was very impatient with those who worried about the weight of an instrument. His great reflector was to weigh about 80 tons, even while he was designing it as an 84-inch; how much it went up in weight after his disk, a 96-inch, was delivered, I do not know. His disk is solid; no folderol for him! "Give me a steel disk with a polish on it, and I'll support it." The donor of the mirror, at first anonymous, must have been ecstatically thanked when he offered to underwrite the cost of a Pyrex disk for the telescope Curtis went to Ann Arbor to build. I am sure Mr. McGregor knew after only a few minutes that Curtis was a man who would spend the money wisely.

On the occasion of my insistence that Curtis should be a member of the Ann Arbor group picture, I had just met Prof. E. W. Brown. While at Virginia, Curtis had studied Brown's lunar theory, and several years later he met Brown, when the latter visited the Lick Observatory. When the two men had settled down in the car for the tortuous trip "up the mountain," Curtis turned to the visitor and said, "I'm glad at last to meet the man who knows so much about the moon's motion. You know, I sometimes pull down my copy of the notes on your lunar theory, and say to myself, 'Good Lord! Did I ever study that?' " To this, Brown replied, "You know, sometimes I pull down my copy of the lunar theory, and say to myself, 'Good Lord! Did I ever write that?' "

R.K.M.

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motions of the celestial bodies. This is not so for astrology. If the hypotheses of astrology looked as promising as the study of gravitational problems, I might well wish to spend more time on its study.

I might finally try to answer the question that has been put to me by my colleagues in astronomy as well as by astrologers. Why do I take any interest at all in astrology? It is frankly not that it seems to me a promising field of study. My main reason is that as an astronomer, whose work is in the last analysis supported by public funds, I consider it one of my functions to take an interest in all public questions that are related to the field of astronomy. If a good portion of the American public is exposed to astrology, it has a right to expect that the astronomers will enlighten it on the subject. It was with this end in view that the American Association of Scientific Workers undertook the study which led to the publication of the article in The SKY and **The Scientific Monthly.** It is for the same reason that I shall continue to bring before the American public the arguments presented in my lecture in New York. By doing so I am not attempting to convert confirmed believers in the mystical powers of the stars and planets, but I hope that I shall be able to be of some service to the average citizen of our country. I hope that the Junior Astronomy Club will try to serve its community by joining with the American Association of Scientific Workers in its attempts to enlighten the public.

Reprinted from the *Junior Astronomy News* for January, 1942.

CLEVELAND

By S. W. McCuskey,

Warner and Swasey Observatory, East Cleveland, Ohio. The dome of the new Schmidt is in the center; at left is the dome of the 9½-inch refractor.

THE atmosphere of the Wade Park Manor, a residential hotel near University Circle in Cleveland, became distinctly astronomical on Sunday afternoon, December 28th, as astronomers from all over the country began to assemble for the 67th meeting of the American Astronomical Society. Infiltration by ones, twos, and larger groups soon resulted in a gathering of a hundred or more. Greetings of friends, informal discussions, and a Council meeting occupied the afternoon.

Some of the early arrivals took advantage of the opportunity offered by Prof. O. L. Dustheimer to visit the new Burrell Memorial Observatory of Baldwin-Wallace College, Berea, Ohio.

The conference of teachers, which has become a more-or-less regular part of the program of society meetings, opened with a lecture by Dr. Frederick Slocum, of the Van Vleck Observatory, on "Stellar Distances." Prof. Slocum traced the historical development of stellar distance measurements from ancient times to the present, and discussed modern parallax methods in some detail. The work of the Van Vleck Observatory at Middletown, Conn., was described as an example of application of the trigonometrical method of determining the distance of a star directly. The speaker outlined, too, the various indirect ways of obtaining stellar parallaxes.

Following the lecture, a committee composed of Prof. S. G. Barton, of the University of Pennsylvania, chairman, Dr. George A. Davis, of the Buffalo Museum of Science, and the Rev. D. J. McHugh, of DePaul University, submitted a report on the pronunciation of astronomical names. The committee has studied in detail the origins of numerous Latin, Greek, and Arabic words which appear in astronomical literature, particularly the names of stars and constellations. Prof. Barton submitted a list of recommended pronunciations, and the other members of the committee amplified particular phases of their work.

The 88 constellation names are included in the recommended list, as well as names of 165 stars. Of these, some 129 are of Arabic origin, and Dr. Davis called attention to the fact that the last syllable of an Arabic word is never accented, even if it is pronounced long, as in Orion. He mentioned particularly the name Mesarthim (γ Arietis), and said it means "an extremely fat ram." Father McHugh also spoke on the original meaning of words.

A timely feature of the conference was a discussion by Major O. E. Henderson of the need for navigators in the U. S. Army Air Corps. Major Henderson and Lt. W. W. Beasley flew to Cleveland from Washington especially to address the astronomical meeting on this problem, and the number of questions and lengthy talks with individuals revealed the widespread interest of astronomers in the war effort.

Applicants for training as "avigators" must be from 20 to 26 years old, married or unmarried, and have the usual other qualifications for entering the Army. The training period covers six months, and when successfully completed enables appointment as Second Lieutenant in the Air Reserve with a rating of Aircraft Observer. All candidates first undergo what is called Aircraft Observer's training. Then comes navigation, with special attention to day and night flights, which for long-range bombers are expected to require continuous celestial navigation. Candidates for bombardier will receive instruction along similar lines, but with bombardier training in place of navigation.

Lt. Beasley said that the need for navigators was more acute than for pilots, and that amateur astronomers and students of astronomy should be particularly at home under the clear skies of the stratosphere, where most long-range bombers will fly.

However, older men with a knowledge of navigation and astronomy are needed to serve as instructors, either by directly enlisting in the Army, or by becoming civilian instructors. This phase of war work seemed to interest a large number of the astronomers present.

On Monday morning at nine o'clock, the society met for the first of four sessions of scientific papers. The general program listed 30 papers, of which 17 were presented in the two sessions on Monday. Elsewhere in this issue are reports on some of the papers.

One of the highlights of the meeting was a lecture by Dr. Harlow Shapley, director of Harvard College Observatory, on Monday evening. This lecture, held in Severance Hall, the home of the Cleveland Symphony Orchestra, was attended by 1,500 persons, and was part of the exercises in dedication of the enlarged Warner and Swasey Observatory of the Case School of Applied Science.

Dr. Shapley spoke on "Galactic Explorations with the Newer Telescopes," an illustrated talk which was an admirable presentation of current astronomical knowledge in a way fully understandable to the large audience. He introduced many new results of galactic researches recently completed or in progress at Harvard.

Among these was the picture of the anti-center region of the galaxy obtained from studies of variable stars and of the distribution of external galaxies in a part of the Milky Way relatively free of interstellar absorption. The short-period Cepheid variable stars were shown to be present at distances of 20,000 or 30,000 light-years from the sun in the direction of Auriga and Taurus, diametrically away from the galactic center. Former researches had already shown the presence of these stars high above and below the galactic plane. This indicates an overall dimension of the galaxy of about 120,000 light-years, as the sun is 30,000 light-years from the galactic center.

However, the star density at this distance is so low that it would perhaps be more appropriate to say that these stars form part of the surrounding haze rather than of the main Milky Way system, according to Dr. Shapley.

A new charting of the galaxies over a large section of the northern sky is one result of the metagalactic survey carried on with the Oak Ridge and South African

ND CONCLAVE

SKEY, ...er and Swasey Observatory

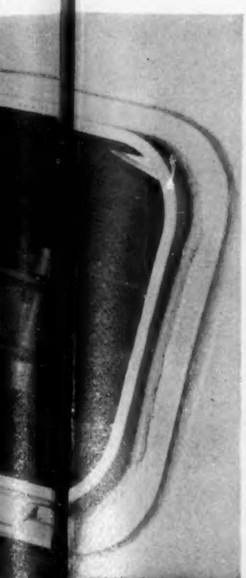
telescopes of Harvard College Observatory. The survey covers 3,600 square degrees of the sky, and borders the Milky Way for 120 degrees. Some of the galaxies charted are 100 million light-years away. The survey has enabled an improved determination of the effect of interstellar absorption on the discovery of galaxies.

Presenting examples of the work carried on with newer telescopes, Dr. Shapley said the Large and Small Magellanic Clouds may form one system, as indicated by the discovery that an appendage of the Small Cloud extends in the direction of the Large Cloud. Along these same lines, latest measurements of the dimensions of spheroidal and spiral galaxies show them to be of about the same relative sizes. From the evidence of ordinary reflecting telescope observations, it has been supposed that spirals were three or four times the diameters of the spheroidal or elliptical forms. Perhaps the new evidence indicates that the arms of spirals are condensations rather than matter thrown out from the central regions.

Following Dr. Shapley's lecture, a reception was held at the Warner and Swasey Observatory in East Cleveland. The enlarged observatory with its newly completed Schmidt-type telescope was open for inspection, and refreshments were served in the Warner Memorial Auditorium. It is in this hall that popular astronomical lectures are given about three times a month during the college year. These facilities for increased public instruction in astronomy are the gift of Mrs. Worcester R. Warner and Miss Helen Warner.

A symposium on "The Schmidt-type Telescope and its Work" was held at the observatory Tuesday morning. Dr. J. J. Nassau, director of Warner and Swasey Observatory, described in some detail the new Burrell telescope, a 24-36-inch Schmidt of f/3.5 focal ratio. This telescope was designed and constructed by the Warner and Swasey Company. Edward P. Burrell, in whose memory the telescope has been given by his widow, Mrs. Katherine Burrell, was the chief engineer of the company and the designer of many of the large telescopes constructed by it.

The Great Nebula in Orion, photographed with the new Burrell telescope of Warner and Swasey Observatory. Exposure, 15 minutes; enlargement, nearly three times.



The photographic plateholder of the Burrell Schmidt telescope in position at the side of the tube for changing plates and adjustment of focus. All engravings on this page, and back-cover photo, courtesy, Warner and Swasey Observatory.

This instrument has a Pyrex mirror, 36 inches clear aperture and of 168-inch radius of curvature. It is coated with chromium and aluminum. The correcting plate is of Vita-glass of 24 inches aperture and thickness 0.3 inches. The plateholder is designed for circular glass plates, 7¾ inches in diameter. Pressure is applied against the back of the plate to bend it to its proper curvature. The plateholder is pivoted to swing to the outside of the telescope tube for loading and unloading.

The mounting is of the cross-axis type. An objective prism of four degrees angle and 24 inches diameter is to be used in obtaining stellar spectra, as is also a proposed diffraction grating. The limiting photographic magnitude of the new telescope on an ordinary night is 18.4 with an exposure of nine minutes using Eastman 103aO plates. The images are equally good throughout the plate.

Dr. Nassau said the instrument was at present engaged in a photometric study in the anti-center region. Blue, yellow, and red magnitudes are being determined in selected areas of apparent obscuration and in clear regions. A similar program in the direction of Cygnus is also contemplated; also, a study of galactic clusters.

The national emergency prevented attendance by James G. Baker, of Harvard, who was scheduled to give a paper on modifications of the Schmidt. In an abstract, read by Dr. Shapley, Mr. Baker said the relatively simple Schmidt can assume many forms, from all-mirror to all-lens combinations. Its apertures can run from a low of f/0.30 to almost any upper limit. Its field can range from several degrees for the fastest cameras to even 180 degrees for cameras of moderate speed (f/3.0). In some forms, it can employ a flat photographic field, instead of the usual curved one.

The third speaker of the symposium was Prof. R. W. Wood, of Johns Hopkins University, who discussed the design and construction of large objective gratings for use with Schmidt telescopes. The problem of obtaining spectra for large numbers of faint stars is highly important in studies of galactic structure. Up to the present thin prisms placed over the telescope objective have been used. These are called objective prisms. Prof. Wood has found, however, that appropriately ruled diffraction gratings are equally satisfactory and possess several advantages. He described his method of ruling metal gratings, casting replicas of them, and mounting these small 4- by 6-inch replicas to form a large mosaic which covered the 18-inch Schmidt at Mt. Palomar. The resulting spectra of nebulae were examined for possible supernovae by Dr. Fritz Zwicky.

Galactic problems to which these newer telescopes are best adapted were discussed by Dr. Bart J. Bok, of Harvard College Observatory, in the concluding symposium paper. He pointed out the need for an extension of the present observational data in two directions: to obtain the colors and spectra of stars fainter than the 12th photographic magnitude; to obtain more accurate spectra and magnitudes for brighter stars. He stressed the limitations imposed on current studies of galactic star densities by the lack of an exact knowledge of the mean absolute magnitudes of the stars of

given spectral classes. To illustrate these restrictions, Dr. Bok presented an analysis for a small region in the southern hemisphere. The star densities per unit volume of space were found to diminish with distance from the sun for all spectral groups except the late *B* and early *A* stars.

Dr. Bok said that at present it was impossible to make a reasonably complete general survey of galactic structure for distances over 1,000 parsecs from the sun, but that Schmidt cameras should extend this distance three times in the next 10 years.

At the Society dinner, in the Wade Park Manor on Tuesday evening, David Dietz, Scripps-Howard science writer, told of the unusual interest in astronomy of the Cleveland public. He said that this was encouraged by the complete cooperation among Cleveland newspapers, astronomers, and amateur astronomers, which made possible public summer star parties attended by as many as 3,000 persons at one time. Mr. Dietz told the astronomers of some of the current advances in sciences other than astronomy.

Society members signed a declaration addressed to the astronomical section of the Russian Academy of Sciences expressing regret at the destruction of Poulkovo Observatory and hope for its speedy rehabilitation.

Col. Philip Fox, well-known American astronomer-soldier, and at present on active duty, gave a stirring and heartfelt talk on the war and some of his personal experiences in the Philippines in the Spanish-American War. His remarks seemed to bring everyone present back to reality after two days of comparatively unburdened scientific thoughts. It was a fitting time for President Joel Stebbins to declare the 67th meeting at an end.

ASTRONOMERS NEEDED

The Naval Observatory in Washington, D. C., is in immediate need of Junior Astronomers. The register of eligibles established as a result of the 1940 examination for Junior Astronomer is entirely exhausted and the U. S. Civil Service Commission has announced another examination to fill positions existing in the Naval Observatory and elsewhere, open to persons under 40 years of age.

Junior Astronomers receive $2,000 a year, while subprofessional positions are open at $1,800 and $1,620 a year.

Because of emergency conditions the usual written test will not be given. Applicants will be rated on education and experience, which must include a four-year college course including or supplemented by 12 semester hours of work in mathematics and 12 semester hours in astronomy. No experience is needed, although appropriate credit will be given for it.

Copies of the examination announcement and application forms may be obtained at any first- or second-class post office or from the Civil Service Commission in Washington, D. C.

NEWS NOTES

By Dorrit Hoffleit

INTERSTELLAR IRON

Drs. Theodore Dunham, Jr., and Walter S. Adams, of Mt. Wilson Observatory, report the discovery of interstellar iron in the spectra of 55 Cygni and χ^2 Orionis. The composition of the material between us and the stars is ascertained from faint absorption lines that appear superposed on the spectra of the hot stars. Ever since the discovery of the lines representative of interstellar ionized titanium and neutral calcium, the Mt. Wilson astronomers have attempted to detect the characteristic lines of neutral iron.

They expected to find these lines very weak, and found slight evidence for their presence on several spectrograms. The presence and the identification of the expected lines at wave lengths 3720 A and 3860 A was definitely confirmed, however, on a spectrum of 55 Cygni exposed for 16 hours. This discovery affords the first reasonably definite evidence of iron in interstellar gases. The intensity of the strongest lines implies an average of about one atom of neutral iron to each cubic meter of space.

METEOR PHOTOGRAPHY WITH A SCHMIDT

Astronomers on Mt. Palomar, busy studying galaxies and supernovae, have fortuitously attained an enviable record in meteor photography.

When Dr. Fletcher Watson, of Harvard College Observatory, visited Mt. Palomar last summer, he examined a sample lot of supernova-patrol photographs taken with the 18-inch Schmidt camera. Among 394 photographs, 81 meteor trails were found, indicating an average of one meteor for every *132 minutes'* exposure time.

Contrast this with the record of Harvard's most efficient meteor-catcher to date—a 1½-inch Ross Xpres lens—which averages only one meteor trail every *100 hours*. The wide-angle lenses heretofore used in meteor photography have suffered seriously from optical imperfections, except for a small area near the center of the field. The field of a Schmidt camera, on the other hand, is optically almost perfect.

Dr. Watson found that the Palomar Schmidt probably reaches meteors between the 2nd and 3rd magnitude (visual) as compared with a limiting magnitude of about —2 for most of the camera-emulsion combinations previously employed by meteor observers. The efficiency of the Schmidt was found to vary with the emulsion used, Agfa Super Pan Press and Eastman 103-O being best for meteors.

The meteors photographed at Palomar are distributed similarly to meteors heretofore observed visually. In the first place they are more numerous in the early morning hours than in the evening—one meteor having been photographed in an average of about 160 minutes between 5:30 and 8:30 p.m., as against one every 100 minutes between 2:30 and 5:30 a.m. Likewise, they are more numerous from October through December than from January through March. Finally, more meteors were photographed at large zenith distances than overhead. Since the majority of meteors reach their greatest brightness at approximately the same distance above the surface of the earth, the effective area photographed is greater at large than at small zenith distances.

HEBER DOUST CURTIS

On the night of January 8th, Dr. Heber Doust Curtis, director of the Observatories of the University of Michigan, died in his sleep at his home at Ann Arbor. Dr. Curtis has been widely known for his work on external galaxies, on solar eclipses (he observed 11), and stellar spectroscopy. Formerly director of the Allegheny Observatory, he became chairman of the Department of Astronomy at Michigan and director of its three observatories in 1930.

Dr. Curtis was to have retired, at the age of 70, this coming June. For an account of his career see The SKY, July, 1941, "Are Astronomers Folks?" by Keivin Burns. Also, see *Astronomical Anecdotes*, this issue.

RELATIVITY PERFECTED

Although relativity has been accepted and applied in all branches of the physical sciences, it has heretofore been proved for only certain special cases. At the Princeton meeting of the American Physical Society, Prof. Albert Einstein announced the final development (after 20 years' work) of his gravitational theory, and showed by a general and rigorous mathematical proof that the theory is applicable in all cases.

HARVARD'S SOUTH AFRICAN SHIPMENTS

Despite the uncertainties in shipping schedules, Harvard continues to receive celestial photographs from its southern station at Bloemfontein, South Africa. Shortly before Christmas a shipment of more than 2,000 plates exposed on southern skies between January and May, 1941, arrived in Cambridge. They contain a wealth of research material on stars, spectra, galaxies, comets, and a few meteors.

One plate, taken with a 1.5-inch Cooke lens on January 27, 1941, shows two comets on the same plate: Comet Cunningham and Comet 1941c. The latter was first announced on January 23rd by Dr. J. S. Paraskevopoulos, who had been searching for Comet Cunningham at Bloemfontein. It had, however, already been discovered on January 15th by de Kock at the Cape of Good Hope, but he had not made his discovery known.

BEGINNER'S PAGE

By Percy W. Witherell

Jupiter, the Giant Planet

As Hesperus (as the Greeks called Venus when an evening star) disappears in the glare of the sun on February 2nd to become Phosphorus, the morning star, the next brightest object in the evening sky (except the moon) is the giant planet Jupiter, now in the constellation Taurus.

Jupiter is well named. It has a diameter about 11 times that of the earth. Its mass is greater than all the other planets combined. Its Hawaiian names, Ikaika (brilliant) and Kaawela (burning) are very appropriate.

Jupiter appears yellowish, with many horizontal belts and numerous irregular areas, of red, brown, orange, olive green, and bluish tints, interposed with bright zones. The form and position of the bands and spots vary considerably from time to time. Their speeds of rotation change and the relative movements of adjacent markings are often very different.

Two of the most famous phenomena are the great red spot (80,000 miles long and 7,000 miles wide) which was conspicuous for over 100 years, and the south tropical disturbance, which is clearly visible at the present time. The red spot gained on the rotation of the general surface of Jupiter and drifted around the planet more than twice. The tropical disturbance traveled 200 miles per hour faster than the red spot and overtook the latter every two to four years. The south disturbance sometimes pulled the spot along at an accelerated speed and then dropped it behind. This shows that we are not observing the fixed surface of the planet, but are seeing clouds of some sort, that are unlike those of the earth.

Although Jupiter has a volume 1,312 times that of the earth, its mass is 317 times, so that its density is only 0.24 the earth's or 1.34 times that of water (specific gravity). Much study has been made of possible models that would meet these conditions. That of Rupert Wildt is fairly satisfactory.

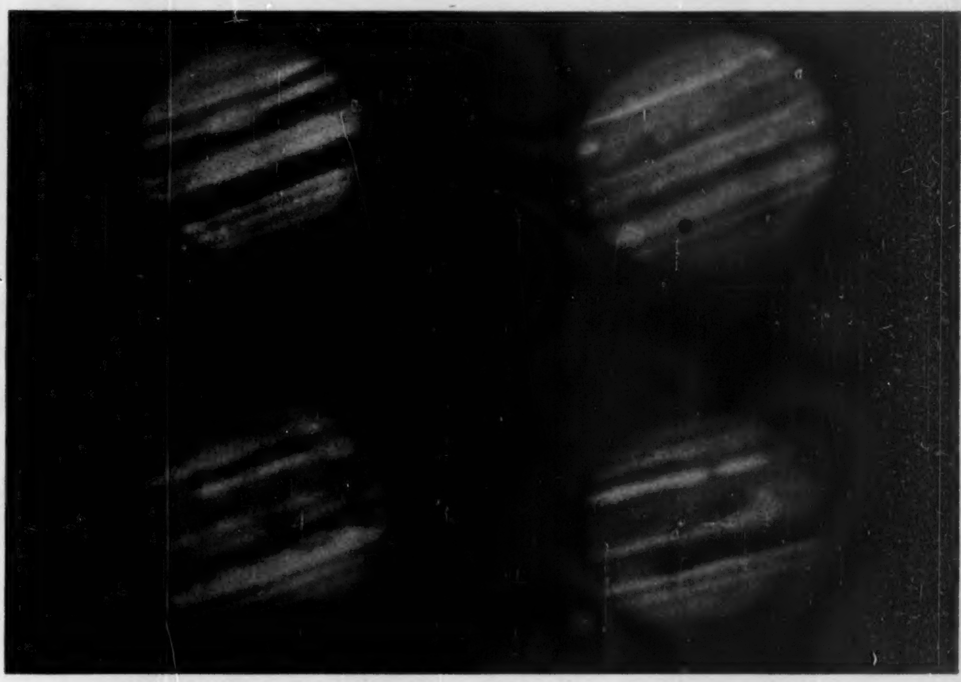
A sphere of rock and metals 37,300 miles in diameter, surrounded by ice 16,900 miles thick, and covered by an atmosphere of 7,800 miles of hydrogen and helium, with ammonia gas and methane (marsh gas) clouds on its surface, fairly represents its structure. If the core has a specific gravity of 6, the compressed ice 1.5, and the atmosphere 0.35, the entire sphere works out to 1.34, as calculated from the mass and volume.

Jupiter receives only 1/900 as much heat from the sun as the earth. As the temperature at the outer surface is but —284°F, and the density and pressure increase rapidly toward the center of the planet, the atmosphere progresses from gas with crystals, to slush, then to a solid state as we approach the center. Carbon dioxide and oxygen are frozen, and hydrogen and helium are probably solid at the bottom of the atmosphere. Unfortunately, the earth's atmosphere prevents an accurate spectrographic determination of the presence of hydrogen and helium. However, the gravitational pull of the massive planet must have prevented their escape, and the presence of compounds of hydrogen—ammonia gas (NH_3) and methane (CH_4)—shows the abundance of this element. Hydrogen and helium are the only elements light enough to give the proper specific gravity of the planet as a whole. These considerations are reasonably consistent with the above model. There are indications of certain metallic elements, notably sodium, in Jupiter's atmosphere.

If the above assumption of the probable composition of Jupiter is true, there can be no life such as we know on the earth.

Jupiter takes 11.86 years to go around its orbit at a mean distance from the sun of 485 million miles. The eccentricity of its elliptical orbit makes a difference of 47 million miles between its nearest and greatest distances from the sun. This variation, in combination with the position of the earth in its orbit, makes it possible for Jupiter to be as near as 367 million miles to the earth, when its magnitude is —2.5, or as far away as 576 million miles, when its magnitude drops to —1.4.

It takes 399 mean solar days for Jupiter to appear in the same relative position to the sun as seen from the earth. This is called its synodic period. In other words, Jupiter appears to move 1/12 of the way along the ecliptic each year, so it moves through one zodiacal constellation annually.



Four photographs of Jupiter made with the 100-inch Hooker telescope. Note changes in the belts and bands; also, the great red spot which shows on the image at upper left. The photos were made:

Upper left, March 28, 1920 — Upper right, March 15, 1921
Lower left, February 12, 1921 — Lower right, May 29, 1922

The shadow of the satellite Ganymede shows against the face of Jupiter in the upper right photograph. All photographs, courtesy, Mt. Wilson Observatory.

The equatorial diameter is 88,640 miles and the polar diameter 82,880 miles, making a mean diameter of 86,720. This oblateness is due to the terrific speed of rotation of 25,000 miles per hour at the equator, for Jupiter, in spite of its size, rotates in 9^h50^m at its equator. In the regions from 10° to 20° N and S, its period of rotation is 9^h55^m. The speeds of different zones vary from time to time. The polar axis is inclined only three degrees, so that there are no seasons.

Jupiter has a family of comets which have been diverted from their original courses to become faithful retainers in long elliptical orbits. The non-appearance of the great shower of Leonids in November, 1899, is blamed on Jupiter's superior attractiveness.

SOUTH AFRICAN ASTRONOMY

The annual report of H. M. Astronomer at the Cape of Good Hope for the year 1940 indicates that half of the observing staff has been engaged in non-astronomical war work. Nevertheless, the depleted staff, assisted by volunteers, is still carrying on its usual observations, though at a somewhat reduced rate.

The number of parallaxes determined at the Cape of Good Hope in 1940 now places it on the very select list of observatories that have measured trigonometrically the distances of more than 1,000 stars. The other observatories sharing this distinction are Allegheny, Leander McCormick, and Yale.

Amateur Astronomers

PITTSBURGH AMATEUR

By Fred Garland—*A.A.A. of Pittsburgh*

IN 1928, Leo Scanlon, a plumber by trade, and Engineer Chester B. Roe obtained a copy of *Amateur Telescope Making* and were inspired to build their own observatory. However, they were not content to work alone, for in 1929 they combed the files of the Carnegie Library to find the names of persons who had recently borrowed books on astronomy. In this way they started the Astronomy Section of the Pittsburgh Academy of Arts and Sciences, which has today grown to the Amateur Astronomers Association of Pittsburgh, with some 200 members.

Four persons attended their first meeting—now more than 100 smoky city amateurs have built or are building their own telescopes, most of them located high enough in the surrounding hills to avoid the "smog" and see the stars.

Leo Scanlon's Valley View Observatory is no exception, as thousands of visitors can testify, if they have taken the long trolley ride out Perrysville Road to the 4300 block, and found the little observatory tucked away on the side of a hill close to the house where Leo has finally settled down to bringing up a family of amateur astronomers.

At present, Leo is about 38 years old and, to quote William Callum in the October, 1937, *Amateur Astronomy*, "built like a good telescope mounting—not too long for his width." He early followed the unique plan of corresponding with all the amateurs whose names he could obtain. He did this originally to benefit by their experience, both in telescope making and observing, but the long-lasting result was that he made friends among amateurs and professionals the world over. His scrapbooks are full of rare communications, confidential notes, and letters from famous amateurs who "don't write letters."

Mr. Callum says further, "One of Leo's important activities is the collecting and arranging of A. T. M. exhibits; he has had many successes in that field. The exhibit at the 1934 meeting of the American Association for the Advancement of Science in the Mellon Institute attracted the attention of Dr. Albert Einstein and we have a photograph of that great scientist in conversation with our great amateur."

Pittsburgh's *Bulletin Index* gave four columns to the amateur astronomers in Pittsburgh in its issue of December 3, 1936, and the reporter wrote:

"Prime Mover Scanlon, blond, mustached, 33-year-old bachelor, has the finest private observatory in the district. With no more than a formal grammar school education to start, Star-gazer Scanlon studied chemistry nights in Allegheny High School, astronomy by mail from Columbia University. His biggest interest outside astronomy is Shakespeare, but he has tied the two up neatly in published articles on 'Shakespeare's References to Astronomy.' . . . Star-gazer Scanlon discovered a 'new' star two years ago. He obtained an image on a photographic plate, checked it with sky maps at Allegheny Observatory and was wildly excited to find no star listed at that spot. Writing post-haste to Harvard University, where all official records are kept, he was informed that the unlisted star had been discovered 40 years before, and omitted from the map through clerical error."

Suddenly descending on Leo Scanlon without warning him, I asked a few questions, the replies to which may interest his many friends among the readers of *Sky and Telescope*:

Q. What was your greatest astronomical thrill?

A. Seeing the planet Saturn with its wonderful rings through my own telescope for the first time (1929).

Q. Did you ever find a comet?

A. Now that is the ambition of every amateur astronomer, and I did a little better in my comet seeking than I did with the "new" star I found. The only trouble, however, was that the comet I found disappeared when I focused my eyepiece properly, and I discovered I had my telescope pointed at an electrical installation on a neighbor's aerial!

Q. We read about professional astronomers, and occasionally amateurs, taking trips to see various phenomena—have you gadded about any for this purpose?

A. I believe the most profound astronomical spectacle I ever witnessed was followed in a few moments by the most embarrassing. It happened during the solar eclipse of 1932. Four Pittsburgh amateurs, including Dr. William Hetzler, of Yerkes, drove 1,500 miles to see the eclipse in New England. Being favored by clear skies, we saw and photographed the corona, also the "diamond ring" effect. My embarrassment was caused by failure to remove a dense red filter on the guiding eyepiece of our battery of cameras, hence the hand guiding had to be done by guesswork, since the light of the corona was too faint to penetrate the filter. I had not practiced removing the filter during daily rehearsals prior to the eclipse.

Q. What kind of work have you done in your observatory and workshop, Leo?

A. I would say, roughly, that I have godfathered more than a hundred telescopes. Through my own instrument I have made many celestial photographs which do not have any great scientific value; but it is an accomplishment many amateurs prize. The educational work my brother Larry and I have done at Valley View brings the greatest returns, because the thousands of school children and visitors who see the moon, planets, and stars for the first time through the telescope get something out of it which they will never lose and always remember.

Q. What has your astronomical work meant to you personally?

A. The formation of enduring friendships. If there had been only a few of these, I would have felt well repaid, but there have been hundreds. Most of them have culminated in personal acquaintances, though many amateurs with whom I have had correspondence for years are still mental images to me.

Q. At meetings of our Association many things happen. What one event stands out for you? (This was a leading question.)

A. There is just one answer: That concerns a friendship with a young lady whom I met at an astronomical gathering one evening in a local park just two years ago. Having a mutual interest in astronomical matters, it was not long until we discovered we had much in common—now a third has joined us, and to him we shall both bequeath our interest in the stars.

Leo Scanlon, Pittsburgh amateur (*left*), talks things over with Russell W. Porter, mentor of amateur telescope makers and consultant on the 200-inch telescope. Mr. Porter was on his way to attend the annual convention of telescope makers at Stellafane, July, 1939.

AMATEUR ASTRONOMERS ASSOCIATION
New York City

On February 4th, *Astronomy and the Public* will be the subject of a lecture by James Stokley, of the General Electric Company. On February 18th, Dr. Charles H. Smiley, of Brown University, will speak on *The Zodiacal Light*.

The public is invited to attend these lectures, at 8:15 p.m., in the Lecture Hall, Roosevelt Memorial Building, American Museum of Natural History, New York City.

STAMFORD ASTRONOMICAL SOCIETY FORMED

On November 17th, a notice appeared in the Stamford (Conn.) *Advocate* that a 10-inch reflecting telescope had been presented to the Stamford Museum, where an astronomical society was to be formed. On December 1st, on the program "The Museum Speaks," over Station WSRR in Stamford, it was announced that the new instrument would be used for a public demonstration on December 8th. The *Advocate* subsequently carried the details, and on the scheduled evening 500 persons gathered at the Town Hall Plaza for a look at Saturn.

The first meeting of the new society was held at the Stamford Museum on December 10th. Dr. G. R. R. Hertzberg, president of the Museum, greeted the new participants in his institution's latest project, and assured them of his full cooperation. He announced the appointment of Robert G. Cox, formerly of New York, as assistant curator of astronomy and chairman of the astronomy committee of the Stamford Museum.

Appointed by the members to act with Mr. Cox on the astronomy committee were: John C. Riley, president; B. F. Whitford, vice-president; and Thomas Page, secretary. It was decided at this first meeting, which was attended by 18 persons, to hold an astronomy class every Wednesday evening, using the textbook, *Astronomy*, by Robert H. Baker. Every fourth Wednesday will be an open-house night with popular talks on astronomy by guest speakers and members.

It was at the regular meeting of the Stamford Junior Chamber of Commerce that Ernest T. Ludhe, curator of the Museum, made the acquaintance of a prospective new member. Mr. Cox had recently moved to Stamford to continue his optical work for the well-known Perkin-Elmer Corp. Together with his fellow employees, he agreed to donate his 10-inch reflector to the Museum if an astronomical society were formed.

Despite the sudden outbreak of war on December 7th, the dedication and public demonstration, sponsored jointly by the Junior Chamber and the Museum, were quite successful. Second Selectman Phillip Hofman represented the town. Saturn was viewed with a power of 100, and even with the brilliant Christmas lighting around the Town Hall it was possible for an experienced eye to see four moons of the planet and Cassini's division in the rings. WSRR transcribed the dedication ceremonies for later broadcast.

Through the cooperative efforts of Dr. Hertzberg, First Selectman George T. Barrett, and Superintendent of Schools Leon C. Staples, it has been arranged to mount the telescope permanently at the Stamford High School, for use by the amateurs, the public, and the schools. Mounting should be completed by spring. Meanwhile, the telescope is being adapted for color photography of the lunar eclipse on March 2nd.

Interest is high despite the call of defense projects. Correspondence with other societies, and with readers of *Sky and Telescope*, is desired.

THOMAS PAGE, secretary
Stamford Astronomical Society

AMATEUR ASTRONOMERS LEAGUE OF AMERICA

Four more societies, in California, Connecticut, Massachusetts, and the District of Columbia, have ratified the proposed by-laws, or suggested changes necessary for final consideration by their members.

On December 6th, the Eastbay Astronomical Association voted to join the League, thus becoming the first society on the West Coast to join.

The Board of Directors of the New Haven Astronomical Society and the Council of the Bond Astronomical Society each approved the proposed by-laws with certain reservations, and subject to final approval by the members of their respective societies.

The National Capital Amateur Astronomers Association stated conditions, similar to those published here in January, necessary for its final ratification of League membership.

POULKOVO OBSERVATORY

(*Continued from page* 4)

relatively unproductive, as is evidenced by the meager results of the observatory's publications.

In 1932 the Soviet government appointed as director the former Kharkov University professor, B. P. Gerasimovich. One of the three best known modern astronomers of Russia, he was a man of great ability and exceptional energy. As a young man he was known for his radical views, and the old czarist government had refused him a statement of political reliability. After the revolution he quickly made a name for himself and was a credit to the entire Soviet astronomy. He spent several years at Harvard College Observatory. While in America his attitude toward his country and its new regime was one of complete loyalty. In 1937 he disappeared in one of the great "purges," and his fate is not known. With him disappeared several other astronomers of Poulkovo, notably N. I. Dneprovsky—the leading positional observer in the U.S.S.R.—and E. J. Perepelkin, the well-known solar worker.

The last director of Poulkovo was again an astronomer of international fame—S. I. Beliavsky, formerly manager of the branch observatory in Simeis in the Crimea. Beliavsky worked on asteroids, comets, and variable stars. He was at one time interested in the Tikhoff-Nordmann phenomenon, and furnished some of the best observations on this subject.

The great majority of Russian astronomers have at one time or another been connected with Poulkovo. In America, A. N. Vyssotsky, now at the Leander McCormick Observatory, was for several years a member of its staff.

The detailed early history of the observatory is recorded in two large volumes, the *Déscription de l'Observatoire Astronomique Central de Poulkovo*, 1843 (by W. Struve), and the *Uebersicht der Tätigkeit der Nikolai-Hauptsterwarte*, 1865 (by O. Struve). The recent history is preserved in the annual reports of the director which appeared until the revolution in 1918, but which have not been received regularly in this country since that time.

The library contained the original manuscripts of Kepler which have never been completely evaluated historically. It is hoped these treasures were safely stored.

A few glimpses of the life at Poulkovo may be added. When the observatory was started there were, of course, no railroads, and all traffic between the observatory and St. Petersburg was by horse-drawn vehicles. In the winter the snow was deep and large sleighs were used. The forest was alive with wolves, and their howls disturbed astronomers at their telescopes at night, and were the terror of the children when they were transported to and from school for the Christmas holidays. After the great Nilalai railroad between St. Petersburg and Moscow was built, it was customary to drive the sleighs or carriages to the station at Czarskoe Selo (now Detskoe Selo) and to have them lifted, for the remainder of the journey, upon a flat car. The passengers preferred to travel in their own conveyances rather than make use of the primitive accommodations in the passenger cars.

The observatory had from the beginning received the attention of Czar Nikolai the First. The Poulkovo hill had been an Imperial estate and the peasant serfs in the village were owned by the government. The serfs were liberated in 1861, but even after that date former government serfs and soldiers, retired after 25 years of mandatory service, were employed for turning the domes and opening the shutters. Most of these men were deeply attached to the observatory and to the astronomers. The story is told of one Dimitri who, on a November evening in 1866, excitedly burst into the room of the director and asked, "What will become of us? The stars are all falling out of the heavens! The government will close the observatory and we shall lose our jobs!"

The observatory frequently entertained distinguished guests. Astronomers from all countries came to see Poulkovo, and because of transportation difficulties were usually entertained in the director's residence. To Poulkovo came the Italian, Schiaparelli, the American, Newcomb, the Royal Astronomer, Airy, and countless others. There came the fierce Prince Shamil of unconquered Georgia, who carried his dagger with him wherever he went. On another occasion the observatory had a visit from the Emir of Bukhara. A few years earlier, one of the many sons of Wilhelm Struve had led in the conquest of Bukhara after a hair-raising escape from prison in the Emir's capital.

Indeed, Poulkovo's "loss will be felt with grief and horror by all astronomers."

BOOKS AND THE SKY

LIVING BIOGRAPHIES OF GREAT SCIENTISTS

HENRY THOMAS and DANA LEE THOMAS. Garden City Publishing Company, Garden City, N. Y., 1941. 314 pages. $1.98.

BIOGRAPHIES of scientists and histories of the development of scientific thought are always welcome, especially when they are well written. *Living Biographies of Great Scientists*, by Henry Thomas and Dana Lee Thomas, is the sixth book in a popular series of biographies by the same authors. Previous works have portrayed the lives of painters, rulers, poets, composers, and philosophers.

In this volume, the authors make up for their lack of adequate scientific background by shifting the emphasis to the personalities of their subjects. Thus, even though their "explanation" of the theory of relativity may be a meaningless paraphrase of popular misconceptions, the book has a moving, gripping message to convey that fully justifies the adjective "living" in the title.

The authors present biographies of 20 eminent scientists: Archimedes, Roger Bacon, Copernicus, Galileo, Newton, Lavoisier, Dalton, Humboldt, Faraday, Darwin, Huxley, Agassiz, Mendel, Pasteur, Kelvin, Haeckel, Steinmetz, Marie Curie, Banting, and Einstein. Would that they had added one more, however—the story of Aristarchus of Samos, whose contributions to astronomy and mathematics have not received the full credit they deserve.

The individual biographies are short, averaging less than 15 pages. The subordination of the scientific to the human element makes them somewhat disappointing, for the reader gains only a dim, if any, impression of the real nature of the contributions the men have made.

The biography of Newton, for example, devotes three precious pages to the boyhood and education of the great scientist. One condensed paragraph gives a summary of Newton's contributions to astronomy and optics; a second vague paragraph attempts somewhat unsuccessfully to picture the nature of his work on mechanics and gravitation, as embodied in the *Principia*. And that is the whole of the scientific content of the chapter. The remainder is a study of Newton's personality, with six full pages devoted to the unproductive period following the scientist's entrance into politics.

I can scarcely forgive the authors for recounting again the myths of Newton's apple and the Archimedian mirrors that set ships on fire. On the credit side, however, is the authors' comment that Archimedes reluctantly gave of his time to produce inventions for military purposes. Apparently the idea of the scientist working for national defense is not new.

As a final note, I must call attention to the series of 20 excellent portraits, reproduced most attractively in duotone gravure. The artist was Gordon Ross. You will probably enjoy the book, but if you should not, the pictures are well worth framing.

DONALD H. MENZEL
Harvard College Observatory

YANKEE STARGAZER
The Life of Nathaniel Bowditch

ROBERT ELTON BERRY. Whittlesey House, New York, 1941. 234 pages. $2.50.

THROUGHOUT history, every time some vital question demanded immediate solution, the good Lord in the fullness of his wisdom inspired someone to invent or to develop the urgently necessary answer.

Navigation, before Nathaniel Bowditch revolutionized it, was a hit-and-miss undertaking. Skippers of ships sailed by dead reckoning, by guesswork, and by feel. They were entirely dependent on inaccurate charts, no chronometers, poor watches, and, last but not least, their own ignorance. Little improvement of such adverse conditions had been made. The great majority of mariners were perfectly willing to let things go as they were, to carry on as their predecessors had, and to trust to God they would reach port. It is small wonder that many ships were lost. The rest were lucky.

Longitude was a deep mystery that few tried to solve. Latitude sailing was slow, awkward, and hazardous. Dead reckoning was inaccurate and frequently dangerous because so little was known of the ocean currents. Hydrography was awaiting the magic touch of Maury to vitalize it. Two Englishmen—Robertson and Maskelyne—had played important parts in the earlier development of navigation. The British government, with its usual "eye out to windward," offered rewards to scientists to solve the baffling problem: "The determination of positions at sea."

John Hamilton Moore, another Englishman, availed himself of the work of his two predecessors, but his effort contained all the errors of Robertson and Maskelyne, to which he had added many more of his own.

In *Yankee Stargazer*, Mr. Berry guilelessly warns us not to think that this is a criticism of Moore's *Practical Navigation*, for it was a much-needed aid to navigation and its form made it very practical even though it contained so many serious errors.

Mr. Edmund M. Blunt, the Salem publisher of Bowditch's work, in thanking the public for its support of the American edition of the *Practical Navigator*, stated that thanks were also due to Moore for what he had done to establish the American work on navigation. Blunt stated, "Moore's work had made it necessary that the United States have its own book since Moore's work had been so erroneous that no person would hazard his interest, much less life, in navigating his vessel by the rules there laid down."

Nathaniel Bowditch's *New American Practical Navigator* contained new methods, refinements, and improvements, and rearrangements of all previous efforts—Moore's, Robertson's, and Maskelyne's. Our own Yankee navigator laboriously corrected not only the 8,000 errors found

in Moore's *Practical Navigator*, but an additional 2,000 which he had traced back to Maskelyne's tables. The *Stargazer* further adds that the little Yankee supercargo had changed forms, added tables, interpolated work pages, and even carried his readers, or should I say students, through a complete voyage copied from his own log book en route from Boston to Madeira. The tremendous value of such details cannot be overestimated. Even to this day, beginners cry for more examples, more footnotes, and more explanations.

Bowditch, although self-taught, became the foremost mathematician in America at the age of 22. Very evidently he was an inspired teacher who could lead the students of his *Practical Navigator* step by step through the intricacies of navigation with the same zest that another would dance with a dashing blonde.

We are told that imitation is the truest flattery. Then, copying must be flattery raised to the *n*th degree. When that hard-headed Yankee, Blunt of Salem, carried a copy of Bowditch's *New American Practical Navigator* across the seas to London and convinced the firm of John and James Hardy and Steele, the publishers ot Moore's *Practical Navigator*, of its outstanding superiority, and made them pay him a "high price" for the single copy, Nathaniel Bowditch was paid the highest compliment that could be made, and one that has been repeated year after year. In ever-increasing volume it has been paid as aspiring navigator, both commercial and naval, has burned the midnight oil over his "Seaman's Bible"—Bowditch. Its popularity is still attested by the sale of 15,000 or more copies of his book last year, 139 years after its first publication.

And this gripping story is told with fascinating simplicity, truthfully, delightfully, and full of thrilling anecdotes, by Robert Elton Berry in his *Yankee Stargazer*. One is not satisfied with merely reading the anecdotes once, but feels impelled to read them again and again for the pure delight of chuckling over such accurately drawn word pictures.

Throughout the narrative, Mr. Berry interpolates many beautiful word etchings. As he unfolds the panorama of ancient Salem, the reader is carried from scene to scene, all delightfully and skillfully sketched. You see vividly and feel keenly all the pathos, the heartaches, the thrills and the triumphs, the backbreaking hardships, and the bitter disappointments of Salem.

And above it all, with the brilliance and beauty of Venus on a clear night, shines the unquenchable fire of Nathaniel Bowditch's genius.

All hands are urged to read the *Yankee Stargazer* and experience the thrill I've just had. My congratulations and my thanks to Mr. Robert Elton Berry.

CAPT. J. F. HELLWEG, U.S.N. Ret.
Supt., U. S. Naval Observatory

NEW WORLDS IN SCIENCE

Edited by Harold Ward. Robert M. McBride and Co., New York, 1941. 670 pages. $3.00.

OF the many excellent scientific books that have poured from the presses in the last decade, most of us can read only a few, and it is largely a matter of chance which ones we miss. Yet often these contain material that would interest us just as much as those we have read.

It is for this reason that Mr. Ward deserves, and will doubtless receive, a hearty vote of thanks for compiling this volume. For what he has done is to comb the recent volumes on many phases of science, and to pick out particularly interesting and striking passages. Some of these extracts are from sources that the layman would not be likely to see, such as the reports of the Rockefeller Foundation, and of the National Resources Committee in Washington.

The result is an anthology of 33 selections by such well-known scientists as Albert Einstein, Robert A. Millikan, Julian Huxley, E. R. Weidlein, Karl T. Compton, George R. Harrison, J. B. S. Haldane, Kirtley F. Mather, and E. A. Hooton.

Divided into two parts, the first group is called "Designs for Living," with such subjects as the antiquity of man, the pattern of evolution, battlefronts in medicine and human biology and politics.

The second part, "The Conquest of Energy," relates mainly to physical sciences. Here we read about the operation of the cyclotron in atom-smashing, the sources of the sun's energy, and possible new sources of power on earth.

In addition to its value to those of us who already have a special interest in science, this book should be for the layman an exciting introduction to what the scientists are doing. For instance, Dr. Raymond B. Fosdick, of the Rockefeller Foundation, gives the thrilling account of the conquest of an African invader of South America. The fact that this invader happened to be a mosquito—the carrier of dreaded African malaria—did not make it any less dangerous than any possible human invader.

Of course, with a book like this, as with the numerous "digest" publications, there is always a danger that such pre-selection for the reader will cause a mental laziness by relieving him of the need of digesting his own intellectual food. However, it may also serve as a sample, and guide the reader to finding more solid nourishment of the same sort.

On the whole, therefore, *New Worlds in Science* is a most welcome addition to scientific literature. This reviewer hopes that future volumes of similar type will appear from time to time.

JAMES STOKLEY
General Electric Company

GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

THE GAVIOLA OR "CAUSTIC" TEST—II

Required Apparatus:

The apparatus required for the caustic test is somewhat more elaborate than that usually found in the amateur's workshop, although no more so than that which is necessary to obtain the best results from the ordinary Foucault test.

We need a light source, of course, and a slit is far preferable to a pinhole. The slit, for best results, should be adjustable from about 1/10 mm. to 1/2 mm. For the knife edge, we need a short piece of wire, carefully mounted parallel to the slit. The diameter of the wire should be slightly smaller than the breadth of the diffraction images of the slit produced by the zones of the mirror. These images will vary, with different mirrors, from about ¼ mm. to about 1½ mm., so it is advisable to provide several wires of varying diameter, mounted parallel to one another in a small frame. Then the most suitable wire can be selected when the tests are made.

The apparatus may be mounted so as to move the source and the wire together, but it would be simpler to hold the source fixed and move only the wire. **In this case, the measured quantities must be halved before determining their deviations from the theoretical values.** If the wire only is to be shifted, care must be taken to see that the source does not come in the line of sight for any of the zones. The displacement of the wire is done with micrometer screws, and there must be provision for movement both along the axis and at right angles thereto. The range of movement along the axis will need to be much greater than that across the axis. Two inches in the former case and one inch in the latter will take care of any mirror up to a 12-inch f/3, the distances increasing as the diameter increases and the focal length decreases. The micrometer screws should read to 1/10,000 of an inch.

The Mirror Mask:

The mirror mask is made of cardboard or other suitable material. The zones to be cut out should be rectangular or elliptical in shape, about twice as high as wide. The width, of course, is the d in equation (5)—see January issue. The zones should be cut out accurately, especially with reference to the position of their centers, since the r in our equations is the distance from the center of the mirror to the center of the zones in question. Care must also be taken to make the zones symmetrical about the center. The maximum width of zone-breadth is given by

$$d = 4.53\ (mR^2)^{1/3}\ 10^{-2}\ \text{cms.} \qquad (6)$$

where m is the aperture-ratio of the given zone.

Having determined the number of zones required (which should always be an odd number, in order to have one located at the center), we proceed to cut out the zonal openings. Although equation (6) indicates that the tolerance increases toward the center, all zones should be made of equal width, including the center zone. It is desirable to cut only alternate zones in the mask, along a horizontal diameter, cutting the zones at the center and extreme edge, and alternate ones between. Then, after these zones are measured, the mask can be moved laterally the width of one zone, and the remainder measured. For example, if the diameter of the mirror were 12½ inches, and the maximum breadth given by (6) for the extreme edge .55 inches, we should take ½ inch as our zonal width, giving us 25 zones on the mirror. We would then cut out the center opening, and six symmetric pairs, each ½ inch wide and 1 inch high, their centers separated by 1 inch. (See Table.)

Procedure of Measurement:

We first measure the radius of curvature of the center zone, and establish the value R. We then move the wire along the axis the distance corresponding to the first pair of zones, as determined by equation (4) (double this amount if the wire only is moved), and then, moving the wire on the transverse screw until it bisects the diffraction image of **one** of the pair of zones, we take a reading. The image given by the corresponding zone of the pair will be on the other side of the axis, and another reading is taken here, and one half the difference of the two readings jotted down beside the B computed from (4). Again, divide this by two if the wire only is moved. From the deviations between the measured and computed B's, h can be determined by equation (5).

TABLE I

Focal Ratio	Mirror Diameter 4¼"	6"	8"	10"	12½"	15"
3	21	23	27	29	31	33
4	17	19	19	21	23	25
5	13	15	17	17	19	19
6	11	13	13	15	15	17
7	9	11	11	13	13	15
8	9	9	11	11	13	13
9	7	9	9	11	11	11
10	7	7	9	9	9	11
12	7	7	7	7	9	9
15	5	5	7	7	7	7

Number of zones required for Gaviola or caustic test. The above table is computed from equation (6) for maximum breadth of zone, converted to inches.

Observation:

This consists of bisecting with the wire the diffraction image produced by the zone, and can be undertaken in one of three ways:

1. Place the eye immediately behind the wire and observe the position for which the intensity of illumination from the zone is a minimum.
2. Use an eyepiece of focal length about ½ inch, and bisect the observed diffraction image with the wire.
3. Place the eyepiece 4 to 6 inches be-

hind the wire and observe the out-of-focus image. Two images will be seen, one formed by the light passing to the left of the wire, and one by the light passing to the right. When these are of equal intensity, the image is bisected.

The third method, being differential, is by far the most exact, but, since the accuracy of the final h will be limited by the accuracy of the micrometer screws used to shift the wire, any of the three methods will lead to an equally precise final result.

As in any scientific observation, many measurements should be made and a mean determined therefrom. Precautions, of course, should be taken against temperature effects (more troublesome in testing small zones than in testing the entire mirror), and other sources of error, such as misalignments, and so on. If we remember that we are actually determining distances of the order of one 10-millionth of an inch, it can be appreciated that precautions are well taken.

Because of the somewhat greater difficulties involved in the caustic test, and because of its extremely high precision, it would seem well to reserve this test for the final checks on a mirror, and use the ordinary Foucault test for qualitative determinations during the figuring process. When the Foucault test shows a good mirror, the caustic test can be called upon to tell just how good it really is.

The caustic test adapts itself well to photography. The images of the slit formed by the various zones can be photographed at some intermediate value of A and the corresponding B-values measured on the plate with ease. In this application, the caustic test is similar to the Hartmann test, but of greater accuracy.

One of the most valuable features of the caustic test is the fact that it can be applied to any type of curve whatever with equal facility. For a caustic can be found for any known curve, even an asymmetric curve. This means that the caustic test can be used on an off-axis parabola, Schmidt correcting plate, Cassegrain secondary, and so on—as easily as on a parabola—with the condition, of course, that convex surfaces must be observed through a converging lens.

Next month we shall give some discussion of the problem of fitting the curve determined by the caustic test to the theoretical paraboloid which will give the smallest average value of h.

For a more complete discussion of the test, development of the equations, and a discussion of the accuracy of Foucault testing in general, see the article by E. Gaviola and Ricardo Platzeck in the **Journal** of the Optical Society of America, Vol. 29, No. 11, November, 1939.

GLEANINGS is always open for comments, contributions, suggestions, and questions, from its readers. We are here to serve, in every possible way, those of the telescope-making fraternity who are among the readers of *Sky and Telescope*.

As previously announced, Technical Bulletins are available as follows: #101, The Schupmann Telescope; #102, Elementary Ray-Tracing Methods; #103, Description of the Common Aberrations.

DO YOU KNOW?

By L. J. Lafleur

EARTH QUIZ

I. Score four points for each question correctly answered, and one point for each question where you do not attempt to select the answer.

1. The summer solstice is the time when the sun is
   a. its extreme distance south of the equator
   b. its extreme distance north of the equator
   c. on the equator going north
   d. on the equator going south
2. The swing of a pendulum cannot be used to
   a. prove the earth is oblate
   b. show that the earth rotates
   c. show that the earth revolves
   d. measure the force of gravitation
3. One of these statements about the positions on the earth's surface of the north pole and the north magnetic pole is true:
   a. they both move
   b. neither moves
   c. only the axial pole moves
   d. only the magnetic pole moves
4. The maximum difference between geocentric and geographic latitude is approximately
   a. 11 degrees c. 11 seconds
   b. 11 minutes d. 0.11 seconds
5. At the equator, a degree of geographic latitude, compared to a degree of geocentric latitude, is
   a. longer b. shorter c. equal
   d. longer if measured north, shorter if measured south
6. The period of revolution of the earth is
   a. longer than that known for any other planet
   b. shorter than that known for any other planet
   c. longer than any except Mars
   d. longer than any except Mercury and Venus
7. The orbit of the earth is
   a. a perfect circle
   b. more nearly circular than that of any other planet
   c. more nearly circular than all but two others
   d. less nearly circular than all but two others
8. The total area of the earth in square miles is approximately
   a. 2,000,000 c. 200,000,000
   b. 20,000,000 d. 2,000,000,000
9. The equatorial diameter of the earth in miles is about
   a. 7,915 c. 7,944
   b. 7,927 d. 7,989
10. The density of the earth in the vicinity of its center is believed to be
    a. about that of iron
    b. almost that of lead
    c. twice that of platinum
    d. over 40 times the densest material known
11. The interior of the earth is known to be
    a. gaseous c. rigid
    b. fluid d. sedimentary
12. The weight of the earth's atmosphere in tons is computed to be several
    a. thousand c. billion
    b. million d. quadrillion
13. The plane of the earth's equator is altered by
    a. the moon's gravitation
    b. the variation of latitude
    c. climatic changes
    d. the revolution of the sun
14. And this alteration is called
    a. militation c. precession
    b. permutation d. eccentricity
15. And it brings it about that
    a. ice ages occur periodically
    b. the first point of Aries is in Pisces
    c. the year grows longer
    d. elastic variations of cosmic laminae accrue

II. Each of the following statements is true. Can you explain why? Count 10 points each, and allow partial credit as you see fit.

1. Rivers in the far north generally curve to the right.
2. The atmosphere not only tends to equalize day and night, but also to raise the average temperature.
3. There are two different reasons for an object weighing more at the north pole than at the equator.
4. The day is growing longer.

(*Answers on page* 24)

THE STORY OF ALGOL

(*Continued from page* 10)

minima. Its spectrum is quite inaccessible in ordinary light; but there is a chance that its lines might be detected in the far infrared. If so, we could determine the mass-ratio and other absolute properties of the eclipsing system much more accurately than we know them today. Experiments in this direction are now in progress at Harvard by William Petrie and the writer; but until the results are known we cannot feel certain as to whether we have reached the final chapter of our story on Algol.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern Standard.

MINIMA OF ALGOL

February 5, 6:17 a.m.; 8, 3:06 a.m.; 10, 11:55 p.m.; 13, 8:45 p.m.; 16, 5:34 p.m.; 28, 4:51 a.m.

Editor's Note: See page 2 for other predicted times. Those given above are based on Mr. Fitzpatrick's own records, as described in his letter to us, in part as follows:

". . . This of course means that all the data in the 1941 *Handbook* was 50 minutes out of the way, which is incredible. Down in Barbados I watched Algol fade out a great many times during the seven years we were on the island. An astronomer from Greenwich Observatory used to run a column once a month in the London *Weekly Times* and in it he gave Algol's minima. I followed him faithfully and learned the mean period to be 2d 20h 48m 56s.

"When we were back in New Rochelle for the summer and fall, I kept this up-to-date and would recheck his figures when we returned to Barbados each winter. I have arbitrarily taken one of these minima from my records—December 24, 1938, and find that 385 periods would produce a minimum at 8:22 p.m. E.S.T., January 1, 1942, instead of 8:05[1] or 8:55.[2] The column in the *Weekly Times* was discontinued when the war started, and so I did not have the data during our last winter and spring in Barbados.

"When you asked me, a year ago, to include these minima, I was afraid to depend upon my own carryover figures and so asked you for a check, which you provided by means of *The Observer's Handbook*. I noticed the discrepancy of 17 minutes, but attributed it to my own carelessness, so you can understand my surprise when they suddenly increased the epoch by 50 minutes in this year's *Handbook*.

"In the January issue of *Popular Astronomy*, there is an article about Algol in which they give the period as 2.867318 days, which equals 2d 20h 48m 56.4s. The extra .4 of a second will increase my 8:22 to 8:24.5. The article also gives the first minimum in 1942 as 8:48 p.m., January 1st. Which is correct?"

[1]*Observer's Handbook*, 1941.
[2]*Observer's Handbook*, 1942.

PHASES OF THE MOON

Full moon	Feb. 1,	4:12 a.m.
Last quarter	Feb. 8,	9:52 a.m.
New moon	Feb. 15,	5:02 a.m.
First quarter	Feb. 22,	10:40 p.m.

Answers to DO YOU KNOW?

(*Questions on page* 23)

I. 1, b; 2, c; 3, a; 4, b; 5, b; 6, d; 7, c; 8, c; 9, b; 10, b; 11, c; 12, d; 13, a; 14, c; 15, b.

II. 1. Rivers flowing north approach the earth's axis, where the velocity of rotation is less, so the momentum of the water tends to force it eastward or to the right. This applies to rivers flowing in any direction in the far north.

2. Infrared radiation from the heated earth does not escape through the atmosphere as easily as sunlight comes in—this is the "greenhouse" effect.

3. At the pole, the surface of the earth is nearer the center; also, there is no centrifugal force from the earth's rotation.

4. Tidal action of the moon and sun acts as a brake on the rotation.

THE PLANETS IN FEBRUARY

Mercury will be too close to the sun for observation.

Venus will reach inferior conjunction with the sun on the 2nd. Due to its retrograde motion, it will draw rapidly away from the sun's glare, and at the end of the month will be a brilliant sight in the early morning sky. It will then be close to the star α Capricorni.

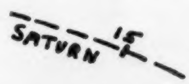
Mars will travel through Aries until the 24th, when it will enter Taurus. On the 17th, it will be in conjunction with and 30 minutes south of δ Arietis, magnitude 4.53. The conjunction with Saturn on the 23rd will not be close. Mars will be north of and separated from Saturn by a distance of 3° 28′.

Jupiter, in Taurus, will retrograde until February 5th, and then resume its progressive motion. Its entire movement for the month will be contained within one degree of arc which will lie one half degree south of the ecliptic.

Saturn will be in Taurus through the month, setting just after midnight. Its magnitude is 0.4.

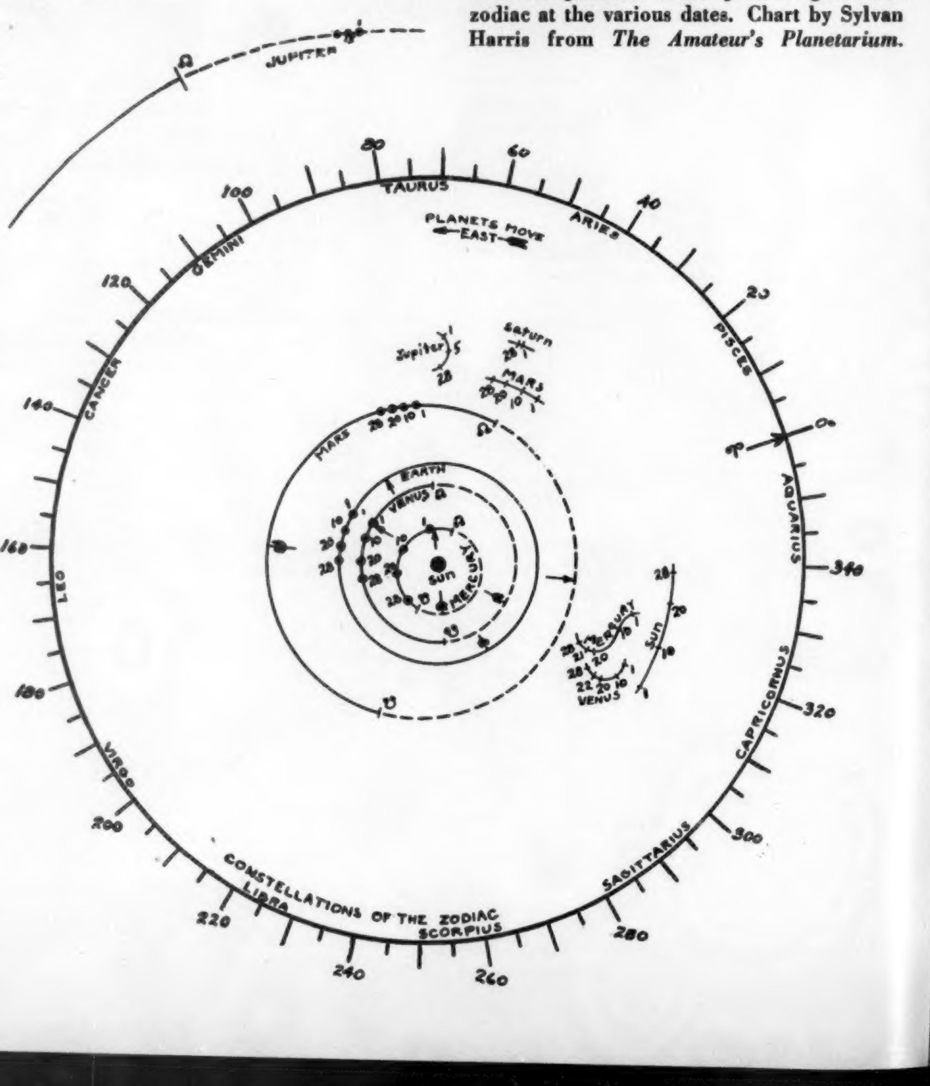
Uranus. The diagram in the November issue shows the course of the planet to the end of its retrograde motion on February 3rd. Its progressive movement will bring it nearer to the ecliptic, but during the balance of the month it will not have advanced far enough to be in conjunction with 13 Tauri.

Neptune. See the article and diagram on page 25.



In the chart below, the orbits of the planets are drawn to scale, and on the orbits are shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.

For convenience, *geocentric* positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates. Chart by Sylvan Harris from *The Amateur's Planetarium*.



OCCULTATIONS—FEBRUARY, 1942

Local station—lat. 40° 48'.6, long. 4h 55.8m west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Feb. 4	6.4	80 Leonis	0:41.7 a.m.	100°	2:00.4 a.m.	311°
5	5.9	13 Virginis	1:45.2 a.m.	144°	2:56.1 a.m.	269°
5	4.0	η Virginis	2:16.8 a.m.	91°	3:30.4 a.m.	323°
7	6.5	623 B Virginis	1:37.7 a.m.	151°	2:33.0 a.m.	255°
7	5.5	95 Virginis	2:42.9 a.m.	112°	4:00.5 a.m.	300°
10	6.5	90 B Ophiuchi	3:24.4 a.m.	128°	4:25.1 a.m.	260°
22	6.0	179 B Tauri	7:03.4 p.m.	114°	8:15.0 p.m.	223°
23	5.7	318 B Tauri	7:23.6 p.m.	46°	8:38.3 p.m.	299°
24	5.5	130 Tauri	7:14.0 p.m.	134°	8:18.3 p.m.	222°
26	5.6	162 B Geminorum	8:08.7 p.m.	115°	9:35.3 p.m.	261°

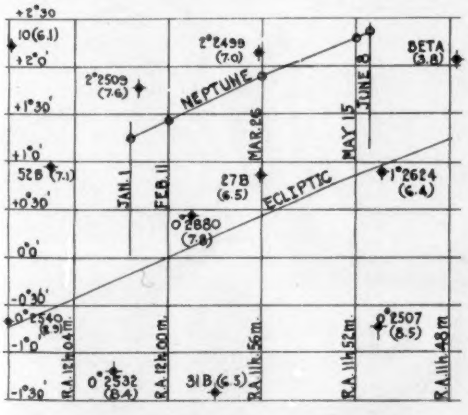
*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

On February 25th, at 10:30.9 p.m., the star 26 Geminorum, magnitude 5.1, will be in close conjunction with the moon. As seen from our local station, the star will be south of the moon's edge by a distance equal to five per cent of the moon's diameter, an angular separation of 1' 30". The position angle of the moon's axis at the moment of conjunction will be 4°.5, bringing the star just south of the easterly edge of the crater Moretus.

THE PLANET NEPTUNE

Neptune will be in retrograde motion until June 8th. Its path will lie approximately 1° 28' north of the ecliptic. Upon resuming its progressive motion after that date, it will move slightly nearer the ecliptic, averaging about 3 minutes closer for the next few months.

I have shown on the diagram the principal stars near this path to be seen at one time in the field of 8×30 binoculars. All of the stars are in Virgo and the amateur can locate them from the position of Beta, the only naked-eye star in the group. Under perfect seeing conditions, all of these stars should be seen with the possible exception of 0°2540, magnitude 8.9. But in order to accomplish this, the binoculars must be held rigid without the slightest vibration. The magnitude of Neptune will be 7.7 through-



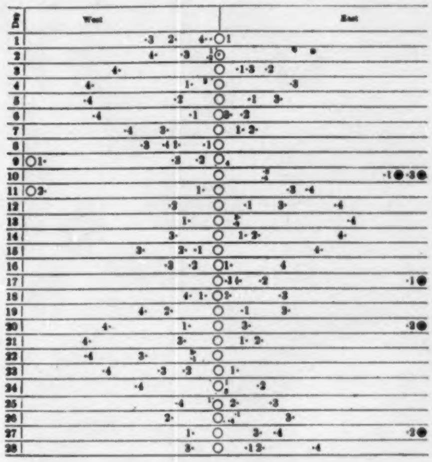
The motion of Neptune from January 1st to June 8th this year can be followed with binoculars, using this chart.

out this period. The magnitudes of the 12 stars in the field are shown in brackets.

On March 22nd, Neptune will be in conjunction with and 16 minutes south of 2°2499. This will be the closest conjunction during the retrograde movement. On June 8th, the planet will be slightly less than one degree east of β Virginis.

JUPITER'S SATELLITES

Jupiter's four bright moons have these positions at 10:30 p.m. E.S.T., on the day preceding the date shown below. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris**.



On February 1st after 10:22 p.m., the four bright moons will be west of the planet and in numerical order, *I* being nearest the primary.

February 7th, throughout the evening and until 0:52 a.m., they will all be west of Jupiter.

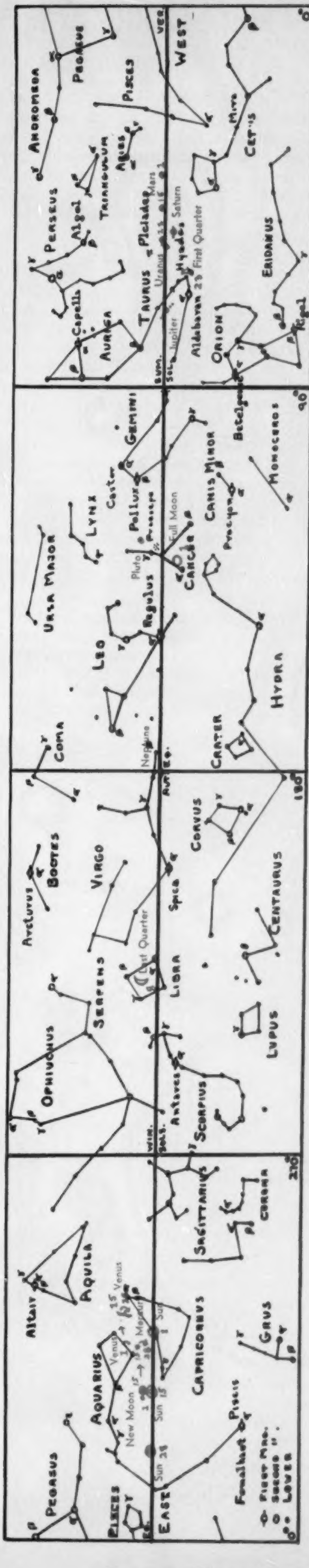
On February 9th after 10:47 p.m., and February 17th after 2:38 a.m., all will be on the east side.

Through the evening of February 21st and until 4:38 a.m., all will be west. After 11:30 p.m. they will be in numerical order, *I* being nearest the primary.

Moon *IV* will be in superior geocentric conjunction at 11:27.5 p.m. February 8th, appearing at that moment just north of the disk.

THE ECLIPTIC CHART

at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer. On the next page is the star chart for this month.



THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

The Starry Heavens in February

By Leland S. Copeland

The Milky Way is a faint but highly important feature of the February night sky. It lies right across the meridian. Passing over the head of Cepheus and the base of Cassiopeia's Chair, in the northwest, it advances through lower Auriga, wanders over the feet of Gemini and between that constellation and Betelgeuze, descends between Procyon and Sirius, and slides through Puppis into regions farther south.

How different is this indistinct mistiness from the glorious white band that crossed the meridian late in August. This contrast, once an enigma, has been explained fully by 20th-century astronomers. They discovered that our earth is about two thirds of the way out from center to circumference of our galaxy. So in February we look rimward across one sixth of our universe, and in August we glance toward five sixths of it, including the center in Sagittarius.

When Galileo entered Rome to submit to the trial that ended in his humiliation, the Milky Way was whispering each night a fact that could crush his enemies:

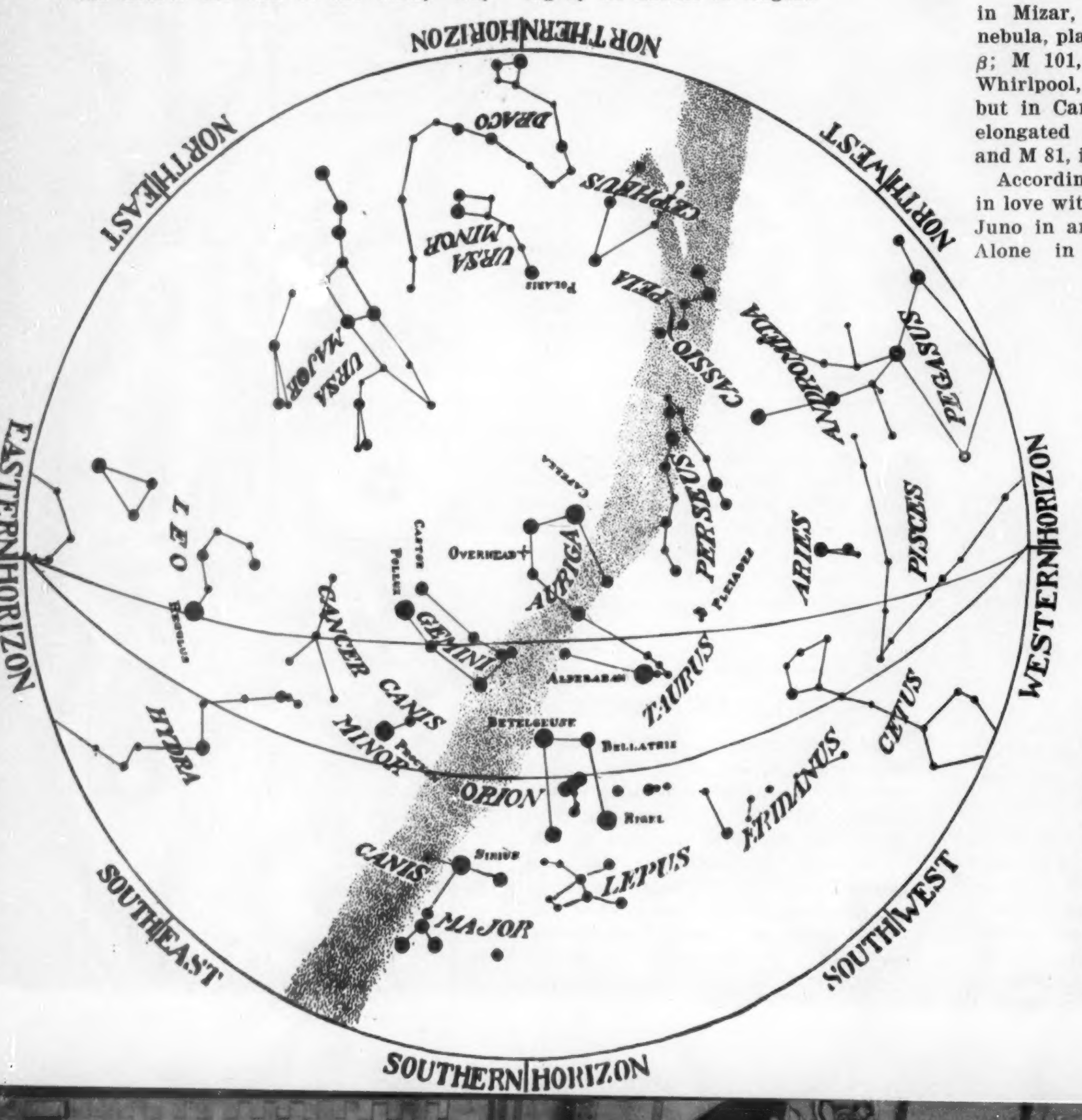
"Even if your globe were the center of the solar system, at least you are tremendously far from the heart of things."

Pondering this problem in the 18th century, Herschel concluded that the earth was nearer the rim of the Milky Way beyond Canis Major than the boundary beyond Aquila. Not only did later investigators verify this, but they discovered that our planet's place was much farther toward the circumference. Now we know that in February we look toward the suburbs; in August, toward the downtown district.

At 9 p.m. in mid-February, Sirius, chief of stars, shines on the meridian in the south, and Alhena (γ Geminorum) is on the same line toward the north. Far south, for dwellers in southern states, Canopus has just crossed the north-south line. Orion, advancing down the western slope, towers above the timid (inconspicuous) Hare. Farther south, between Lepus and Canopus, flies the dim Dove, chiefly four stars, close together.

Hydra and Leo are high in the east, where clustered Coma Berenices follows the Lion. Toward the west Cetus partly has disappeared, and Alpheratz, head of Andromeda, approaches the horizon.

In the northeast the Big Dipper stands on its handle. A Rule of Nine will help us to remember the seasonal positions of this group. On the ninth day at 9 p.m. the Big Dipper is directly below the north pole in November, directly east of the pole in February, directly north and upside down in May, directly west and hanging by its handle in August.



THE SEVEN STARS

For ages seven stars have circled on the northern wall of night. They have caught the attention of almost everyone who has lived on this planet. We call them the Big Dipper. To Homer they were the Bear or Wain; to Julius Caesar, the Seven Plow Oxen.

At the dawn of history they were a mysterious shining symbol, instilling a reverence for seven that never has faded from the human mind. About 2500 B.C., when priests of pre-Babylonia were beginning to design our constellation figures, the Seven Stars revolved even closer to the north pole. They and due north were then almost identical. Thus may have arisen the idea that seven was the ideal number.

Later this was strengthened by recognition of other starry groups, such as the Pleiades and the Northern Crown; by the lunar phases, and by the seven planets known to the ancients. So the Big Dipper may be the earliest source of our week.

But Ursa Major has more than seven stars. To know the Great Bear we must be able to find "the doe's leaps"—sets of twin stars that mark three of Bruin's paws. Also we must recognize the V of dim stars, its head, and the curve, ending in κ and ι, that outlines one front leg.

Even the Big Dipper has more than seven stars. Sharp eyes can detect a dozen in its bowl, where large telescopes find many thousands. Far back of these is a supergalaxy.

Owners of amateur telescopes delight in Mizar, double star, in handle; Owl nebula, planetary, at bottom of bowl, near β; M 101, spiral, above end of handle; Whirlpool, double galaxy, under handle but in Canes Venatici; M 82, handsome elongated galaxy (9h 52m, $+$ 69° 56′) and M 81, its oval and dimmer companion.

According to the old story, Jupiter fell in love with Callisto, a beauty of Arcadia. Juno in anger changed her into a bear. Alone in the woods, the lost lady feared all wild creatures. One day when her son Arcas was hunting, she ventured near to give him a big hug. The frightened boy would have shot her if Jupiter had not transformed them into constellations. At Juno's request Neptune punished Callisto further by ordering that the former glamour girl never again should have a bath. So the Bear, as she wheels round the pole, "hath no part in the ocean baths," as *The Odyssey* inexactly reports.

THE STARS FOR FEBRUARY as seen from mid-northern latitudes at 9 p.m., February 7th; 8 p.m., February 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic crosses near the center, the equator below it. See chart on the Observer's Page for the positions of the sun, moon, and planets this month.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*Hour*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	Bond Ast. Club	1st Thu.	8:15 p.m.	Oct.-June	Harvard Observatory	Homer D. Ricker, Harvard Observatory
"	A.T.M.s of Boston	2nd Thu.	8:15 p.m.	Sept.-June	Harvard Observatory	F. I. Noyes, 340 Warren St., Brockton, Mass.
BROOKLYN, N. Y.	Astr. Dept., B'klyn Inst.	Round Table 3rd Thu.	8:00 p.m.	Oct.-April	Brooklyn Institute	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & Observers	1st & 3rd Fri.	8:00 p.m.	Oct.-June	Museum of Science	J. J. Davis, Museum of Science
CHATTANOOGA	Barnard A. S.	4th Fri.	7:30 p.m.	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	Burnham A. S.	2nd & 4th Tue.	8:00 p.m.	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CLEVELAND	Cleveland A. S.	Fri.	8:00 p.m.	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH, FLA.	D. B. Stargazers	Alt. Mon.	8:00 p.m.	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	Detroit A. S	2nd Sun.	3:00 p.m.	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	Northwest A. A. S.	1st & 3rd Tue.	8:00 p.m.	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	Duluth Ast. Club	1st & 3rd Sat.	8:00 p.m.	All year	Darling Observatory	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	Tex. Observers	No reg. meetings	....			Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A. A.	1st Thu.	7:30 p.m.	All year	Ala. Power Auditorium	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	Indiana A. A.	1st Sun.	2:00 p.m.	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
LOS ANGELES	L. A. A. S.	2nd Thu.	8:15 p.m.	......	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'ville A. S.	3rd Tue.	8:00 p.m.	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	Mad. A. S.	2nd Wed.	8:00 p.m.	All year	Washburn Observatory	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	Milw. A. S.	1st Thu.	8:00 p.m.	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	Pop. Ast. Club	2nd Tue.	7:30 p.m.	All year	Sky Ridge Observatory	Carl H. Gamble, Route 1
NEW HAVEN	New Haven A. A. S.	1st Sat.	8:00 p.m.	Sept.-June	Yale Observatory	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A. A. A.	1st & 3rd Wed.	8:15 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	Junior Ast. Club	Alt. Sat.	8:00 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00 p.m.	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	Eastbay A. A.	1st Sat.	8:00 p.m.	Sept.-June	Chabot Observatory	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. of F.I.	3rd Fri.	8:00 p.m.	All year	The Franklin Institute	Edwin F. Bailey, *Rit.* 3050
"	Rittenhouse A. S.	2nd Fri.	8:00 p.m.	Oct.-May	The Franklin Institute	A. C. Schock, *Rit.* 3050
PITTSBURGH	A. A. A. of P'burgh	2nd Fri.	8:00 p.m.	Sept.-June	Buhl Planetarium	F. M. Garland, 1006 Davis Ave., N.S.
PORTLAND, ME.	A. S. of Maine	2nd Fri.	8:00 p.m.	All year	Private Homes	H. M. Harris, 27 Victory Ave., S. Portland
PROVIDENCE, R. I.	Skyscrapers	1st Wed.	8:00 p.m.	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	Reading-Berks A. C.	2nd Thu.	8:00 p.m.	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A. S. of Nev.	4th Wed.	....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00 p.m.	Oct.-May	Eastman Bldg., Univ. of Rochester	P. W. Stevens, 1179 Lake Ave., *Glenwood* 5233-*R*
SAN ANTONIO	San Ant. A. A.	3rd Mon.	8:00 p.m.	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'tady Ast. Club	3rd Mon.	8:00 p.m.	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	St. Joseph Val. Ast.	Last Tue.	8:00 p.m.	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	Stamford Ast. Soc.	4th Wed.	8:00 p.m.	All year	Stamford Museum	Thomas Page, Stamford Mus., 300 Main St.
TACOMA, WASH.	Tacoma A. A.	1st Mon.	....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D. C.	Nat'l. Cap. A. A. A.	1st Sat.	8:00 p.m.	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	Wichita A. S.	2nd Tue.	8:00 p.m.	All year	East High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148

Sky and Telescope is official publication of many of these societies.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ THE BUHL PLANETARIUM presents *February 1-12,* TRIP THRU SPACE; *February 13-28,* MYTHS AND MARVELS.

The Buhl Planetarium presents, February 1-12, "Trip Thru Space," a sky show in which visitors—after a bird's-eye view of the earth—take leave of our planet and are whisked out into far regions of space on a streamlined dash to other worlds. On this imaginary jaunt thru the trackless universe, we investigate the mysteries of the moon and Mars and other nearby worlds. Then, out beyond, to explore the galaxies themselves. Beginning February 13th, the Buhl Planetarium presents for the remainder of the month "Myths and Marvels." Here we listen to the strange star stories of so long ago, as full of interest and beauty in this twentieth century as they were in the misty, forgotten eras of antiquity. With the Planetarium stage we are carried back to the glory that was Greece, when the men of old Athens wove their fanciful tales of the glittering stars above. And in the Planetarium sky we see the characters of those tales—whether king, princess or dragon—come suddenly and colorfully to life.

★ THE HAYDEN PLANETARIUM presents in *February,* WAVES FROM SPACE. (See page 5.)

All that man knows about the heavenly bodies he has learned through the agency of light. By correctly interpreting the messages of light, the astronomer has discovered what the stars are made of, how fast they are traveling, and in what directions. He has begun to understand those invisible radiations—X-rays, ultraviolet, infrared—and most mysterious of all emanations from outer space, the cosmic rays which constantly bombard the earth. In February the Hayden Planetarium dramatizes these cosmic forces in a parade of *Waves From Space.*

★ SCHEDULE BUHL PLANETARIUM

Mondays through Fridays .... 3, 8, and 9 p.m.
Saturdays .... 2, 3, 8, and 9 p.m.
Sundays and Holidays .... 3, 4, 8, and 9 p.m.

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Business Manager,* Frank S. McGary; *Public Relations,* John J. Grove; *Curator of Exhibits,* Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays .... 2, 3:30, and 8:30 p.m.
Saturdays .... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast .... 9:30-10:00 a.m.
Sundays and Holidays .... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Assistant Curators,* Marian Lockwood, Robert R. Coles.

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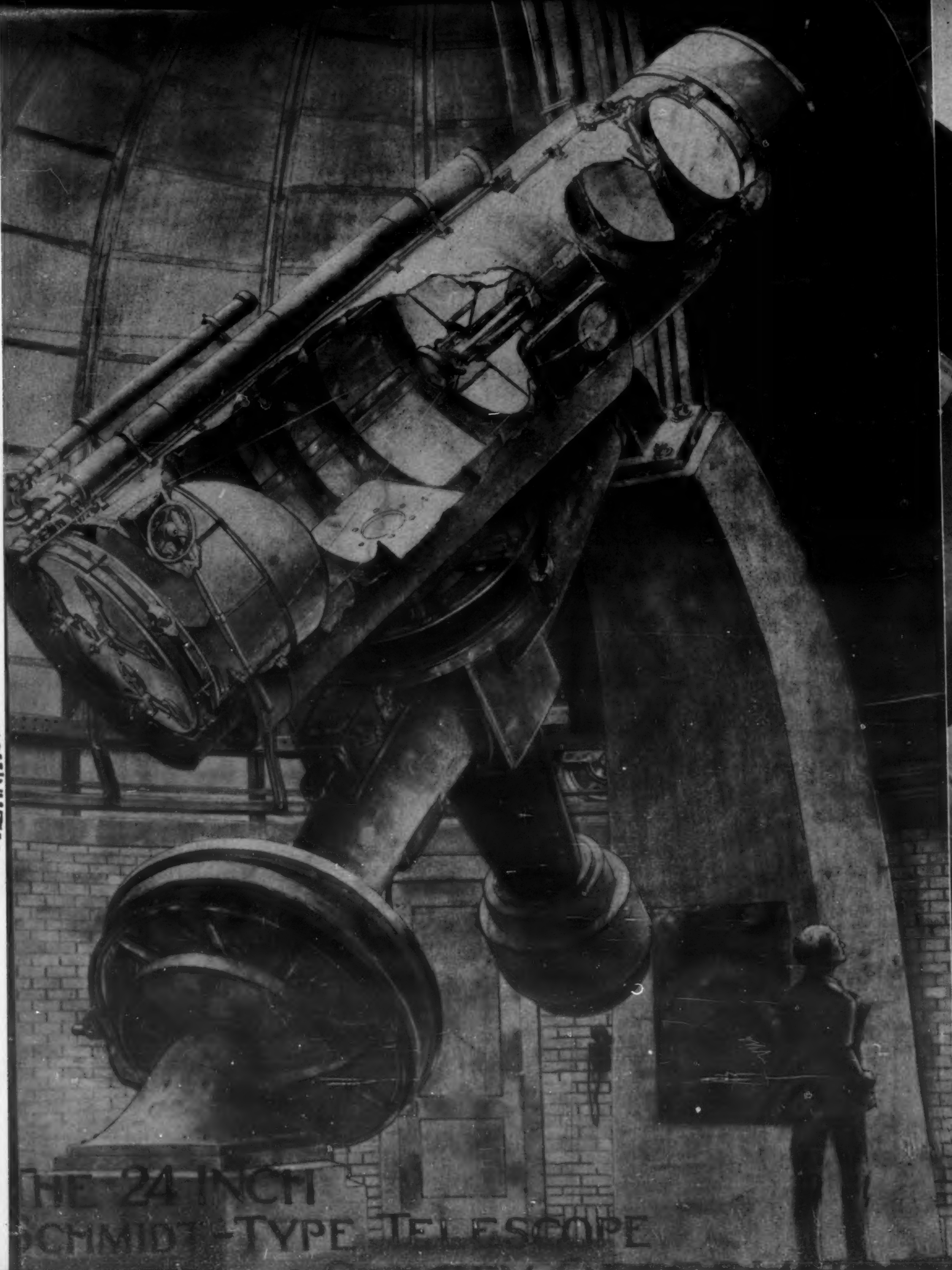

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